General Instructions:

Read the following instructions very carefully and follow them:

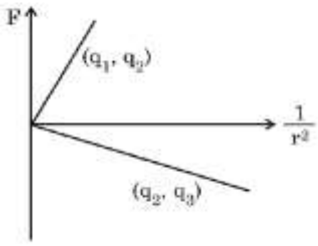
(i) This question paper contains 33 questions. All questions are compulsory.
(ii) Question paper is divided into FIVE sections - Sections A, B, C, D and. E
(iii) In Section A: Question numbers 1 to 16 are Multiple Choice (MCQ) type questions. Each question carries 1 mark.
(iv) In Section B: Question numbers 17 to 21 are Very Short Answer (VSA) type questions. Each question carries 2 marks.
(v) In Section C: Question numbers 22 to 28 are Short Answer (SA) type questions. Each question carries 3 marks.
(vi) In Section D: Question numbers 29 & 30 are Case Study-Based questions. Each question carries 4 marks.
(vii) In Section E: Question numbers 31 to 33 are Long Answer (LA) type questions. Each question carries 5 marks.
(viii) There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the Sections except Section A.
(ix) Kindly note that there is a separate question paper for Visually Impaired candidates.
(x) Use of calculators is NOT allowed.

You may use the following values of physical constants wherever necessary:

$c = 3 \times 10^8$ m/s
$h = 6.63 \times 10^{-34}$Js
$e = 1.6 \times 10^{-19}$C
$\mu_0 = 4\pi \times 10^{-7}\text{TmA}^{-1}$
$\varepsilon_0 = 8.854 \times 10^{-12}\text{C}^2\ \text{N}^{-1}\ \text{m}^{-2}$
$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ \text{N m}^2\text{C}^{-2}$
Mass of electron $(m_e) = 9.1 \times 10^{-31}$ kg.
Mass of neutron $= 1.675 \times 10^{-27}$ kg.
Mass of proton $= 1.673 \times 10^{-27}$ kg.
Avogadro's number $= 6.023 \times 10^{23}$ per gram mole
Boltzmann's constant $= 1.38 \times 10^{-23}\text{JK}^{-1}$

SECTION - A

1. Figure shows variation of Coulomb force (F) acting between two point charges with $\frac{1}{r^2}$, r being the separation between the two charges (q_1, q_2) and (q_2, q_3). If q_2 is positive and least in magnitude, then the magnitudes of q_1, q_2 and q_3 are such that



(a) $q_2 < q_3 < q_1$ (b) $q_3 < q_1 < q_2$
(c) $q_1 < q_2 < q_3$ (d) $q_2 < q_1 < q_3$

2. Two wires P and Q are made of the same material. The wire Q has twice the diameter and half the length as that of wire P. If the resistance of wire P is R, the resistance of the wire Q will be

(a) R (b) $\frac{R}{2}$
(c) $\frac{R}{8}$ (d) 2 R

3. A 1 cm segment of a wire lying along x -axis carries current of 0.5 A along $+x$ direction. A magnetic field $\vec{B} = (0.4\text{mT})\hat{j} + (0.6\text{mT})\hat{k}$ is switched on, in the region. The force acting on the segment is

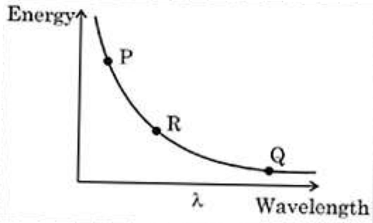
(a) $(2\hat{j} + 3\hat{k})$mN (b) $(-3\hat{j} + 2\hat{k})\mu$N
(c) $(6\hat{j} + 4\hat{k})$mN (d) $(-4\hat{j} + 6\hat{k})\mu$N

4. **A coil has 100 turns, each of area $0.05\ m^2$ and total resistance 1.5Ω. It is inserted at an instant in a magnetic field of 90 mT, with its axis parallel to the field. The charge induced in the coil at that instant is:**
(a) 3.0 mC (b) 0.30 C
(c) 0.45 C (d) 1.5 C

5. **You are required to design an air-filled solenoid of inductance 0.016 H having a length 0.81 m and radius 0.02 m . The number of turns in the solenoid should be**
(a)2592 (b) 2866
(c) 2976 (d) 3140

6. **A voltage $\nu = \nu_0 \sin \omega t$ applied to a circuit drives a current $i = i_0 \sin(\omega t + \phi)$ in the circuit. The average power consumed in the circuit over a cycle is**
(a)Zero (b) $i_0 \nu_0 \cos\phi$
(c) $\frac{i_0 \nu_0}{2}$ (d) $\frac{i_0 \nu_0}{2} \cos\phi$

7. **The given diagram exhibits the relationship between the wavelength of the electromagnetic waves and the energy of photon associated with them. The three points P, Q and R marked on the diagram may correspond respectively to :**



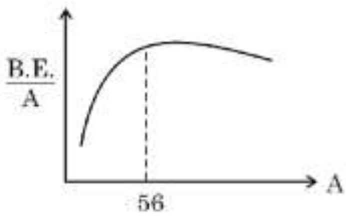
(a)X-rays, microwaves, UV radiation
(b) X-rays, UV radiation, microwaves
(c) UV radiation, microwaves, X-rays
(d) Microwaves, UV radiation, X-rays

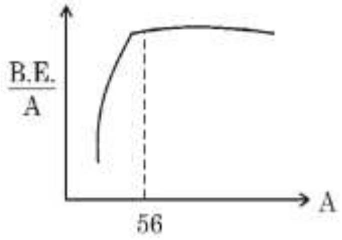
8. **A beaker is filled with water (refractive index $\frac{4}{3}$) upto a height H. A coin is placed at its bottom. The depth of the coin, when viewed along the near normal direction, will be**
(a)$\frac{H}{4}$ (b) $\frac{3H}{4}$
(c) H (d) $\frac{4H}{3}$

9. **The stopping potential V_0 measured in a photoelectric experiment for a metal surface is plotted against frequency ν of the incident radiation. Let m be the slope of the straight line so obtained. Then the value of charge of an electron is given by (h is the Planck's constant.)**
(a) mh (b) $\frac{m}{h}$
(c) $\frac{h}{m}$ (d) $\frac{1}{mh}$

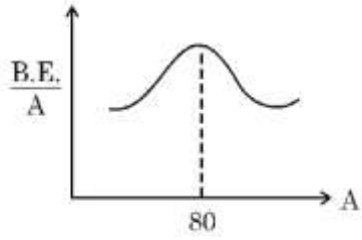
10. **Let λ_e, λ_p and λ_d be the wavelengths associated with an electron, a proton and a deuteron, all moving with the same speed. Then the correct relation between them is**
(a)$\lambda_d > \lambda_p > \lambda_e$ (b) $\lambda_e > \lambda_p > \lambda_d$
(c) $\lambda_p > \lambda_e > \lambda_d$ (d) $\lambda_e = \lambda_p = \lambda_d$

11. **Which of the following figures correctly represent the shape of curve of binding energy per nucleon as a function of mass number?**

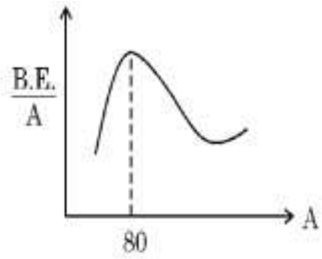
(a)




(b)



(c)



(d)

12. When a p-n junction diode is forward biased

(a)the barrier height and the depletion layer width both increase.

(b) the barrier height increases and the depletion layer width decreases.

(c) the barrier height and the depletion layer width both decrease.

(d) the barrier height decreases and the depletion layer width increases.

Question numbers 13 to 16 are Assertion (A) and Reason (R) type questions. Two statements are given - one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (a), (b), (c) and (d) as given below :

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

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

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

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

13. Assertion (A): It is difficult to move a magnet into a coil of large number of turns when the circuit of the coil is closed.

Reason (R): The direction of induced current in a coil with its circuit closed, due to motion of a magnet, is such that it opposes the cause.

14. Assertion (A): The deflection in a galvanometer is directly proportional to the current passing through it.

Reason (R) : The coil of a galvanometer is suspended in a uniform radial magnetic field.

15. Assertion (A): We cannot form a p− n junction diode by taking a slab of a p− type semiconductor and physically joining it to another slab of a n− type semiconductor.

Reason(R): In a p− type semiconductor $\eta_e \gg \eta_h$ while in a n−type semiconductor $\eta_h \gg \eta_e$.

16. Assertion(A): The potential energy of an electron revolving in any stationary orbit in a hydrogen atom is positive .

Reason(R): The total energy of a charged particle is always positive.

SECTION−B

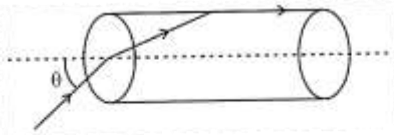
17. A battery of emf E and internal resistance r is connected to a rheostat. When a current of 2 A is dawn from the battery, the potential difference across the rheostat is 5 V. The potential difference becomes 4 V when a current of 4 A is drawn from the battery. Calculate the value of E and r .

18. **(a) In a diffraction experiment, the slit is illuminated by light of wavelength 600 nm.The first minimum of the pattern falls at $\theta = 30°$. Calculate the width of the slit.**

OR

(b) In a Young's double - slit experiment, two light waves, each of intensity I_0,interfere at a point, having a path difference $\frac{\lambda}{8}$ on the screen. Find the intensity at this point.

19. **A transparent solid cylindrical rod (refractive index $\frac{2}{\sqrt{3}}$) is kept in air. A ray of light incident on its face travels along the surface of the rod, as shown in figure. Calculate the angle θ .**



20. **Prove that, in Bohr model of hydrogen atom, the time period of revolution of an electron in n^{th} orbit is proportional to n^3 .**

21. **A p-type Si semiconductor is made by doping an average of one dopant atom per 5×10^7 silicon atoms. If the number density of silicon atoms in the specimen is 5×10^{28} atoms m^{-3}, find the number of holes created per cubic centimetre in the specimen due to doping. Also give one example of such dopants.**

SECTION - C

22. **(a)** Two batteries of emf's 3 V&6 V and internal resistances 0.2Ω&0.4Ω are connected in parallel. This combination is connected to a 4Ω resistor. Find :

(i) the equivalent emf of the combination

(ii) the equivalent internal resistance of the combination

(iii) the current drawn from the combination

OR

(b) (i) A conductor of length l is connected across an ideal cell of emf E. Keeping the cell connected, the length of the conductor is increased to $2l$ by gradually stretching it. If R and R' are initial and final values of resistance and v_d and $v_d{}'$ are initial and final values of drift velocity, find the relation between (i) R' and R and (ii) v_d' and v_d.

(ii) When electrons drift in a conductor from lower to higher potential, does it mean that all the 'free electrons' of the conductor are moving in the same direction?

23. **Using Biot - Savart law, derive expression for the magnetic field ($\vec{B}$) due to a circular current carrying loop at a point on its axis and hence at its centre.**

24. **(a)Show that the energy required to build up the current I in a coil of inductance L is $\frac{1}{2}LI^2$.**

(b) Considering the case of magnetic field produced by air-filled current carrying solenoid, show that the magnetic energy density of a magnetic field B is $\frac{B^2}{2\mu_0}$.

25. **(a)A parallel plate capacitor is charged by an ac source. Show that the sum of conduction current (I_c) and the displacement current (I_d) has the same value at all points of the circuit.**

(b) In case (a)above, is Kirchhoff's first rule (junction rule) valid at each plate of the capacitor? Explain.

26. **Answer the following giving reason :**

(a)All the photo electrons do not eject with the same kinetic energy when monochromatic light is incident on a metal surface.

(b) The saturation current in case (a)is different for different intensity.

(c) If one goes on increasing the wavelength of light incident on a metal surface, keeping its intensity constant, emission of photo electrons stop at a certain wavelength for this metal.

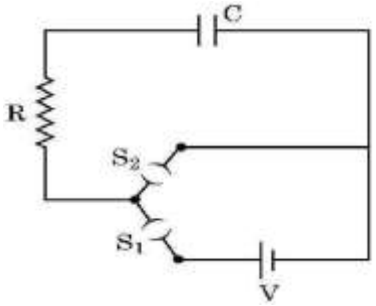
27. **(a) Define 'Mass defect' and 'Binding energy' of a nucleus. Describe 'Fission process' on the basis of binding energy per nucleon.**

(b) A deuteron contains a proton and a neutron and has a mass of 2.013553 u . Calculate the mass defect for it in u and its energy equivalence in MeV. ($m_p = 1.007277u, m_n = 1.008665u, 1u = 931.5MeV/c^2$)

28. **(a)Draw circuit arrangement for studying V-I characteristics of a p-n junction diode.**
(b) Show the shape of the characteristics of a diode.
(c) Mention two information that you can get from these characteristics.

SECTION - D

29. **Question numbers 29 and 30 are case study- based questions. Read the following paragraphs and answer the questions that follow.**
A circuit consisting of a capacitor C, a resistor of resistance R and an ideal battery of emf V, as shown in figure is known as RC series circuit.

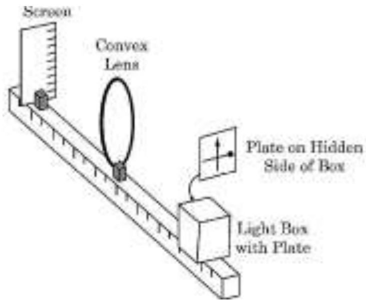


As soon as the circuit is completed by closing key S_1 (keeping S_2 open) charges begin to flow between the capacitor plates and the battery terminals. The charge on the capacitor increases and consequently the potential difference $V_c(=q/C)$ across the capacitor also increases with time. When this potential difference equals the potential difference across the battery, the capacitor is fully charged ($Q = VC$). During this process of charging, the charge q on the capacitor changes with time t as $q = Q[1 - e^{-t/RC}]$
The charging current can be obtained by differentiating it and using $\frac{d}{dx}(e^{mx}) = me^{mx}$.
Consider the case when $R = 20k\Omega, C = 500\mu$ F and $V = 10$ V.
(i) The final charge on the capacitor, when key S_1 is closed and S_2 is open, is
(a)$5\mu C$ (b) 5 mC
(c) 25 mC (d) 0.1 C
(ii) For sufficient time the key S_1 is closed and S_2 is open. Now key S_2 is closed and S_1 is open. What is the final charge on the capacitor ?
(a)Zero (b) 5 mC
(c) 2.5 mC (d) $5\mu C$
(iii) The dimensional formula for RC is
(a)$[ML^2 T^{-3} A^{-2}]$ (b) $[M^0 L^0 T^{-1} A^0]$
(c) $[M^{-1} L^{-2} T^4 A^2]$ (d) $[M^0 L^0 T A^0]$
(iv) The key S_1 is closed and S_2 is open. The value of current in the resistor after 5 seconds, is
(a)$\frac{1}{2\sqrt{e}}$ mA (b) $\sqrt{e}$mA
(c) $\frac{1}{\sqrt{e}}$ mA (d) $\frac{1}{2e}$ mA

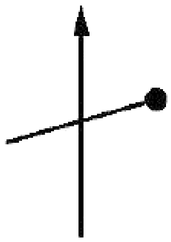
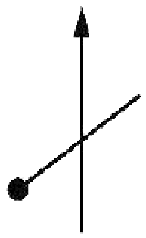
OR

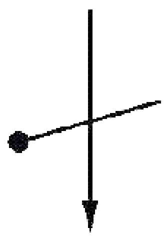
(iv) The key S_1 is closed and S_2 is open. The initial value of charging current in the resistor, is
(a)5 mA (b) 0.5 mA
(c) 2 mA (d) 1 mA

30. **A thin lens is a transparent optical medium bounded by two surfaces, at least one of which should be spherical. Applying the formula for image formation by a single spherical surface successively at the two surfaces of a lens, one can obtain the 'lens maker formula' and then the 'lens formula'. A lens has two foci - called 'first focal point' and 'second focal point' of the lens, one on each side.**



(i)
Consider the arrangement shown in figure. A black vertical arrow and a horizontal thick line with a ball are painted on a glass plate. It serves as the object. When the plate is illuminated, its real image is formed on the screen.
Which of the following correctly represents the image formed on the screen?


(a)

(b)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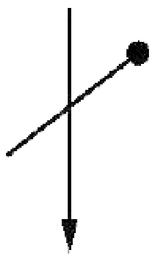

(d)

(ii) Which of the following statements is incorrect?
(a)For a convex mirror magnification is always negative.
(b) For all virtual images formed by a mirror magnification is positive.
(c) For a concave lens magnification is always positive.
(d) For real and inverted images, magnification is always negative.
(iii) A convex lens of focal length ' f ' is cut into two equal parts perpendicular to the principal axis. The focal length of each part will be :
(a)f (b) 2 f
(c) $\frac{f}{2}$ (d) $\frac{f}{4}$

OR

(iii) If an object in case (i) above is 20 cm from the lens and the screen is 50 cm away from the object, the focal length of the lens used is
(a)10 cm (b) 12 cm
(c) 16 cm (d) 20 cm
(iv) The distance of an object from first focal point of a biconvex lens is X_1 and distance of the image from second focal point is X_2. The focal length of the lens is
(a)X_1X_2 (b) $\sqrt{X_1+X_2}$
(c) $\sqrt{X_1X_2}$ (d) $\sqrt{\frac{X_2}{X_1}}$

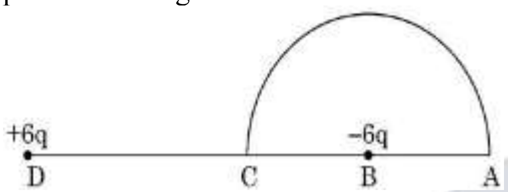
SECTION - E

31. (a)(i) Two point charges $5\mu C$ and $-1\mu C$ are placed at points (-3 cm , 0,0) and (3 cm, 0,0) respectively. An external electric field $\vec{E}=\frac{A}{r^2}\hat{r}$ where $A=3\times10^5$Vm is switched on in the region. Calculate the change in electrostatic energy of the system due to the electric field.
(ii) A system of two conductors is placed in air and they have net charge of $+80\mu C$ and $-80\mu C$ which causes a potential difference of 16 V between them.

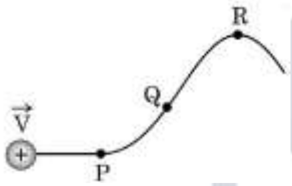
(1) Find the capacitance of the system.
(2) If the air between the capacitor is replaced by a dielectric medium of dielectric constant 3 , what will be the potential difference between the two conductors?
(3) If the charges on two conductors are changed to $+160 \mu C$ and $-160 \mu C$, will the capacitance of the system change ? Give reason for your answer.

OR

(b) (i) Consider three metal spherical shells A, B and C, each of radius R. Each shell is having a concentric metal ball of radius R/10. The spherical shells A, B and C are given charges $+6q, -4q$, and $14q$ respectively. Their inner metal balls are also given charges $-2q, +8q$ and $-10q$ respectively. Compare the magnitude of the electric fields due to shells A, B and C at a distance $3R$ from their centres.
(ii) A charge $-6 \mu C$ is placed at the centre B of a semicircle of radius 5 cm , as shown in the figure. An equal and opposite charge is placed at point D at a distance of 10 cm from B . A charge $+5 \mu C$ is moved from point ' C ' to point ' A ' along the circumference. Calculate the work done on the charge.



32. (a)(i)A proton moving with velocity $\vec{V}$ in a non-uniform magnetic field traces a path as shown in the figure.



The path followed by the proton is always in the plane of the paper. What is the direction of the magnetic field in the region near points P, Q and R ? What can you say about relative magnitude of magnetic fields at these points ?
(ii) A current carrying circular loop of area A produces a magnetic field B at its centre. Show that the magnetic moment of the loop is $\frac{2BA}{\mu_0}\sqrt{\frac{A}{\pi}}$.

OR

(b)(i) Derive an expression for the torque acting on a rectangular current loop suspended in a uniform magnetic field.
(ii) A charged particle is moving in a circular path with velocity $\vec{V}$ in a uniform magnetic field $\vec{B}$. It is made to pass through a sheet of lead and as a consequence, it looses one half of its kinetic energy without change in its direction. How will (1) the radius of its path (2) its time period of revolution change ?

33. (a)(i)(1) What are coherent sources ? Why are they necessary for observing a sustained interference pattern ? Lights from two independent sources are not coherent.Explain.
(ii) Two slits 0.1 mm apart are arranged 1.20 m from a screen. Light of wavelength 600 nm from a distant source is incident on the slits.
(1) How far apart will adjacent bright interference fringes be on the screen ?
(2) Find the angular width (in degree) of the first bright fringe.

OR

(b)(i) Define a wavefront. An incident plane wave falls on a convex lens and gets refracted through it. Draw a diagram to show the incident and refracted wavefront.
(ii)A beam of light coming from a distant source is refracted by a spherical glass ball(refractive index 1.5) of radius 15 cm . Draw the ray diagram and obtain the position of the final image formed.

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$e = 1.6 \times 10^{-19}$C
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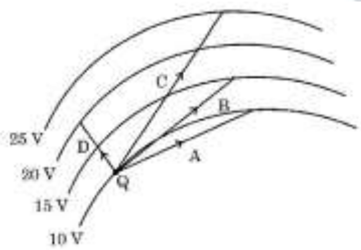
$\varepsilon_0 = 8.854 \times 10^{-12}\mathrm{C^2\ N^{-1}\ m^{-2}}$
$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ \mathrm{N\ m^2C^{-2}}$
Mass of electron $(m_e) = 9.1 \times 10^{-31}$ kg.
Mass of neutron $= 1.675 \times 10^{-27}$ kg.
Mass of proton $= 1.673 \times 10^{-27}$ kg.
Avogadro's number $= 6.023 \times 10^{23}$ per gram mole
Boltzmann's constant $= 1.38 \times 10^{-23}\mathrm{JK^{-1}}$

SECTION – A

34. In the figure curved lines represent equipotential surfaces. A charge Q is moved along different paths A, B, C and D. The work done on the charge will be maximum along the path



(a) A (b)B
(c)C (d)D

35. The resistance of a wire of length L and radius r is R. Which one of the following would provide a wire of the same material of resistance $\frac{R}{2}$?

(a)Using a wire of same radius and twice the length
(b)Using a wire of same radius and half length
(c)Using a wire of same length and twice the radius
(d)Using a wire of same length and half the radius

36. A 1 cm segment of a wire lying along x -axis carries current of 0.5 A along $+x$ direction. A magnetic field $\vec{B} = (0.4\mathrm{mT})\hat{j} + (0.6\mathrm{mT})\hat{k}$ is switched on, in the region. The force acting on the segment is

(a)$(2\hat{j} + 3\hat{k})$Mn (b)$(-3\hat{j} + 2\hat{k})\mu$N
(c)$(6\hat{j} + 4\hat{k})$mN (d)$(-4\hat{j} + 6\hat{k})\mu$N

37. A circular coil of diameter 15 mm having 300 turns is placed in a magnetic field of 30 mT such that the plane of the coil is perpendicular to the direction of magnetic field. The magnetic field is reduced uniformly to zero in 20 ms and again increased uniformly to 30 mT in 40 ms . If the emfs induced in the two time intervals are e_1 and e_2 respectively, then the value of e_1/e_2 is

(a)$\frac{1}{2}$ (b)1

(c)2 (d)4

38. You are required to design an air-filled solenoid of inductance 0.016 H having a length 0.81 m and radius 0.02 m . The number of turns in the solenoid should be

(a)2592 (b)2866

(c)2976 (d)3140

39. A voltage $v = v_0 \sin \omega t$ applied to a circuit drives a current $i = i_0 \sin(\omega t + \phi)$ in the circuit. The average power consumed in the circuit over a cycle is

(a)Zero (b)$i_0 v_0 \cos \phi$

(c)$\frac{i_0 v_0}{2}$ (d)$\frac{i_0 v_0}{2} \cos \phi$

40. Which one of the following correctly represents the change in wave characteristics (all in vacuum) from microwaves to X-rays in electromagnetic spectrum?

	Speed	Wavelength	Frequency
(A)	Remains same	Decreases	Remains same
(B)	Remains same	Decreases	Increases
(C)	Increases	Increases	Decreases
(D)	Remains same	Increases	Remains same

41. The speed of light in two media ' 1 ' and ' 2 ' are v_1 and $v_2 (> v_1)$ respectively. For a ray of light to undergo total internal reflection at the interface of these two media, it must be incident from

(a)medium ' 1 ' and at an angle greater than $\sin^{-1}\left(\frac{v_1}{v_2}\right)$

(b)medium ' 1 ' and at an angle greater than $\cos^{-1}\left(\frac{v_1}{v_2}\right)$

(c)medium '2' and at an angle greater than $\sin^{-1}\left(\frac{v_1}{v_2}\right)$

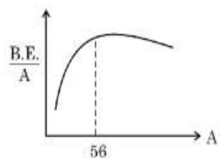
(d)medium ' 2 ' and at an angle greater than $\cos^{-1}\left(\frac{v_1}{v_2}\right)$

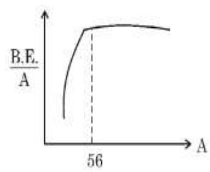
42. A source produces monochromatic light of frequency 5.0×10^{14} Hz and the power emitted is 3.31 m W. The number of photons emitted per second by the source, on an average is

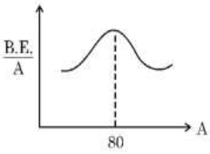
(a)10^{16} (b)10^{24}

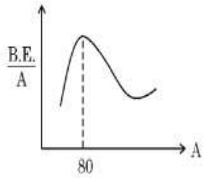
(c)10^{10} (d)10^{20}

43. Which of the following figures correctly represent the shape of curve of binding energy per nucleon as a function of mass number?

(a)


(b)


(c) 

(d) 

44. When a p-n junction diode is forward biased

(a)the barrier height and the depletion layer width both increase.

(b)the barrier height increases and the depletion layer width decreases.

(c)the barrier height and the depletion layer width both decrease.

(d)the barrier height decreases and the depletion layer width increases.

45. Let λ_e, λ_p and λ_d be the wavelengths associated with an electron, a proton and a deuteron, all moving with the same speed. Then the correct relation between them is

(a)$\lambda_d > \lambda_p > \lambda_e$ (b)$\lambda_e > \lambda_p > \lambda_d$

(c)$\lambda_p > \lambda_e > \lambda_d$ (d)$\lambda_e = \lambda_p = \lambda_d$

Question numbers 13 to 16 are Assertion (A) and Reason (R) type questions. Two statements are given - one labelled Assertion (a)and the other labelled Reason (R). Select the correct answer from the codes (A), (B), (C) and (d) as given below.

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

(B)Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of Assertion (A).

(C)Assertion (A)is true, but Reason (R) is false.

(D)Assertion (A)is false and Reason (R) is also false.

46. Assertion (A): The potential energy of an electron revolving in any stationary orbit in a hydrogen atom is positive.

Reason (R): The total energy of a charged particle is always positive.

47. Assertion (A): We cannot form a p-n junction diode by taking a slab of a p-type semiconductor and physically joining it to another slab of a n-type semiconductor.

Reason (R) : In a p-type semiconductor $\eta_e \gg \eta_h$ while in a n-type semiconductor $\eta_h \gg \eta_e$.

48. Assertion (A): The deflection in a galvanometer is directly proportional to the current passing through it.

Reason (R): The coil of a galvanometer is suspended in a uniform radial magnetic field.

49. Assertion (A): It is difficult to move a magnet into a coil of large number of turns when the circuit of the coil is closed.

Reason (R) : The direction of induced current in a coil with its circuit closed, due to motion of a magnet, is such that it opposes the cause.

SECTION – B

50. Show that $\vec{E} = \rho\vec{j}$ leads to Ohm's law. Write a condition in which the Ohm's law is not valid for a material.

51. (a)In a diffraction experiment, the slit is illuminated by light of wavelength 600 nm . The first minimum of the pattern falls at $\theta = 30°$. Calculate the width of the slit.

OR

(b)In a Young's double-slit experiment, two light waves, each of intensity I_0, interfere at a point, having a path difference $\frac{\lambda}{8}$ on the screen. Find the intensity at this point.

52. A spherical convex surface of radius of curvature R separates glass (refractive index 1.5) from air. Light from a point source placed in air at distance R/2 from the surface falls on it. Find the position and nature of the image formed.

53. The energy of an electron in an orbit of Bohr hydrogen atom is -3.4 eV . Find its angular momentum.

54. A p-type Si semiconductor is made by doping an average of one dopant atom per 5×10^7 silicon atoms. If the number density of silicon atoms in the specimen is 5×10^{28} atoms m^{-3}, find the number of holes created per cubic centimetre in the specimen due to doping. Also give one example of such dopants.

SECTION - C

55. (a)Two batteries of emf's 3 V & 6 V and internal resistances $0.2\Omega \& 0.4\Omega$ are connected in parallel. This combination is connected to a 4Ω resistor. Find:

(i) the equivalent emf of the combination

(ii) the equivalent internal resistance of the combination

(iii) the current drawn from the combination

OR

(b)(i) A conductor of length l is connected across an ideal cell of emf E. Keeping the cell connected, the length of the conductor is increased to $2l$ by gradually stretching it. If R and R$'$ are initial and final values of resistance and v_d and $v_d{}'$ are initial and final values of drift velocity, find the relation between (i) R' and R and (ii) v'_d and v_d.

(ii) When electrons drift in a conductor from lower to higher potential, does it mean that all the 'free electrons' of the conductor are moving in the same direction?

56. (a)Define magnetic moment of a current-carrying coil. Write its SI unit.

(b)A coil of 60 turns and area 1.5×10^{-3} m^3 carrying 2 A current lies in a vertical plane. It experiences a torque of 0.12 Nm when placed in a uniform horizontal magnetic field. The torque acting on the coil changes to 0.05 Nm after the coil is rotated about its diameter by 90°, in the magnetic field. Find the magnitude of the magnetic field.

General Instructions :

Read the following instructions very carefully and follow them:

(i) This question paper contains 33 questions. All questions are compulsory.
(ii) Question paper is divided into FIVE sections - Sections A, B, C, D and. E
(iii) In Section A : Question numbers 1 to 16 are Multiple Choice (MCQ) type questions. Each question carries 1 mark.
(iv) In Section B : Question numbers 17 to 21 are Very Short Answer (VSA) type questions. Each question carries 2 marks.
(v) In Section C : Question numbers 22 to 28 are Short Answer (SA) type questions. Each question carries 3 marks.
(vi) In Section D : Question numbers 29 & 30 are Case Study-Based questions. Each question carries 4 marks.
(vii) In Section E : Question numbers 31 to 33 are Long Answer (LA) type questions. Each question carries 5 marks.
(viii) There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the Sections except Section A.
(ix) Kindly note that there is a separate question paper for Visually Impaired candidates.
(x) Use of calculators is NOT allowed.

You may use the following values of physical constants wherever necessary:

$c = 3 \times 10^8$ m/s
$h = 6.63 \times 10^{-34}$Js
$e = 1.6 \times 10^{-19}$C
$\mu_0 = 4\pi \times 10^{-7} TmA^{-1}$
$\varepsilon_0 = 8.854 \times 10^{-12} C^2 N^{-1} m^{-2}$
$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 N m^2 C^{-2}$
Mass of electron $(m_e) = 9.1 \times 10^{-31}$ kg.
Mass of neutron $= 1.675 \times 10^{-27}$ kg.
Mass of proton $= 1.673 \times 10^{-27}$ kg.
Avogadro's number $= 6.023 \times 10^{23}$ per gram mole
Boltzmann's constant $= 1.38 \times 10^{-23} JK^{-1}$

SECTION-A

57. Two charges $-q$ each are placed at the vertices A and B of an equilateral triangle ABC. If M is the mid-point of AB, the net electric field at C will point along

(a) CA (b) CB

(c) MC (d) CM

58. A student has three resistors, each of resistance R. To obtain a resistance of $\frac{2}{3}R$, she should connect

(a)all the three resistors in series.

(b)all the three resistors in parallel.

(c)two resistors in series and then this combination in parallel with the third resistor.

(d)two resistors in parallel and then this combination in series with the third resistor.

59. A 1 cm straight segment of a conductor carrying 1 A current in x direction lies symmetrically at origin of Cartesian coordinate system. The magnetic field due to this segment at point (1 m, 1 m, 0) is

(a)$1.0 \times 10^{-9}\hat{k}$T (b)$-1.0 \times 10^{-9}\hat{k}$T

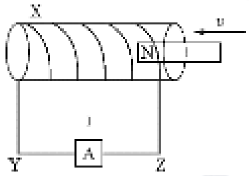
(c)$\frac{5.0}{\sqrt{2}} \times 10^{-10}\hat{k}$T (d)$-\frac{5.0}{\sqrt{2}} \times 10^{-10}\hat{k}$T

60. The magnetic field due to a small magnetic dipole of dipole moment ' M ' at a distance ' r ' from the centre along the axis of the dipole is given by

(a)$\frac{\mu_0}{4\pi} \times \frac{2M}{r^3}$ (b)$\frac{\mu_0}{4\pi} \times \frac{M}{r^3}$

(c)$\frac{\mu_0}{4\pi} \times \frac{M}{2r^3}$ (d)$\frac{\mu_0}{4\pi} \times \frac{2M}{r^2}$

61. In the figure X is a coil wound over a hollow wooden pipe.

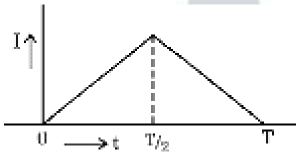


A permanent magnet is pushed at a constant speed v from the right into the pipe and it comes out at the left end of the pipe. During the entry and the exit of the magnet, the current in the wire YZ will be from

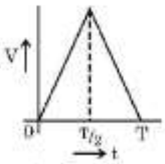
(a)Y to Z and then Y to Z (b)Z to Y and then Y to Z

(c)Y to Z and then Z to Y (d)Z to Y and then Z to Y

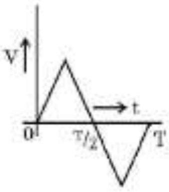
62. The alternating current I in an inductor is observed to vary with time t as shown in the graph for a cycle.



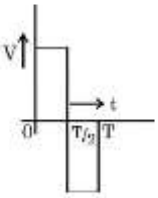
Which one of the following graphs is the correct representation of wave form of voltage V with time t ?



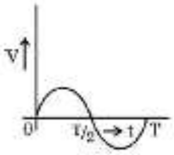
(a)



(b)



(c)



(d)

63. A transformer is connected to a 200 V ac source. The transformer supplies 3000 V to a device. If the number of turns in the primary coil is 450, then the number of turns in its secondary coil is -

(a)30 (b)450

(c)4500 (d)6750

64. Which one of the following statements is correct ?

Electric field due to static charges is
(a)conservative and field lines do not form closed loops.
(b)conservative and field lines form closed loops.
(c)non-conservative and field lines do not form closed loops.
(d)non-conservative and field lines form closed loops.

65. **A tub is filled with a transparent liquid to a height of 30.0 cm. The apparent depth of a coin lying at the bottom of the tub is found to be 16.0 cm. The speed of light in the liquid will be**
(a)1.6×10^{8} m s^{-1} (b)2.0×10^{8} m s^{-1}
(c)3.0×10^{8} m s^{-1} (d)2.5×10^{8} m s^{-1}

66. **Atomic spectral emission lines of hydrogen atom are incident on a zinc surface. The lines which can emit photoelectrons from the surface are members of**
(a)Balmer series
(b)Paschen series
(c)Lyman series
(d)Neither Balmer, nor Paschen nor Lyman series

67. **The energy of an electron in a hydrogen atom in ground state is -13.6 eV. Its energy in an orbit corresponding to quantum number n is -0.544 eV. The value of n is**
(a)2 (b)3
(c)4 (d)5

68. **When the resistance measured between p and n ends of a p-n junction diode is high, it can act as a/an -**
(a)resistor (b)inductor
(c)capacitor (d)switch

For Questions 13 to 16, two statements are given - one labelled Assertion (a)and other labelled Reason (R). Select the correct answer to these questions from the codes (A), (B), (c)and (d)as given below :
(a)If both Assertion (a)and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(b)If both Assertion (a)and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
(c)If Assertion (a)is true but Reason (R) is false.
(d)If both Assertion (a)and Reason (R) are false.

69. **Assertion (A):** In a semiconductor diode the thickness of depletion layer is not fixed.
Reason (R): Thickness of depletion layer in a semiconductor device depends upon many factors such as biasing of the semiconductor.

70. **Assertion (A):** In Bohr model of hydrogen atom, the angular momentum of an electron in n^{th} orbit is proportional to the square root of its orbit radius r_n.
Reason (R) : According to Bohr model, electron can jump to its nearest orbits only.

71. **Assertion (A):** Out of Infrared and radio waves, the radio waves show more diffraction effect.
Reason (R): Radio waves have greater frequency than infrared waves.

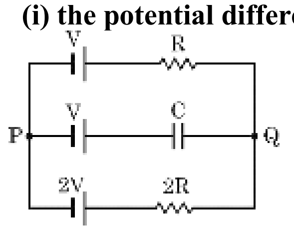
72. **Assertion (A):** In an ideal step-down transformer, the electrical energy is not lost.
Reason (R): In a step-down transformer, voltage decreases but the current increases.

SECTION - B

73. **(a)Two wires of the same material and the same radius have their lengths in the ratio 2: 3. They are connected in parallel to a battery which supplies a current of 15 A . Find the current through the wires.**

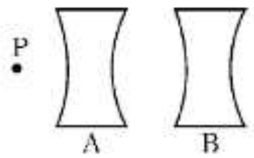
OR

(b)In the circuit three ideal cells of e.m.f. V, V and 2 V are connected to a resistor of resistance R , a capacitor of capacitance C and another resistor of resistance 2 R as shown in figure. In the steady state find (i) the potential difference between P and Q and (ii) potential difference across capacitor C.



74. In a double-slit experiment, 6^{th} dark fringe is observed at a certain point of the screen. A transparent sheet of thickness t and refractive index n is now introduced in the path of one of the two interfering waves to increase its phase by $2\pi(n-1)t/\lambda$. The pattern is shifted and 8^{th} bright fringe is observed at the same point. Find the relation for thickness t in terms of n and λ.

75. Two concave lenses A and B, each of focal length 8.0 cm are arranged coaxially 16 cm apart as shown in figure. An object P is placed at a distance of 4.0 cm from A . Find the position and nature of the final image formed.



76. A light of wavelength 400 nm is incident on metal surface whose work function is 3.0×10^{-19} J. Calculate the speed of the fastest photoelectrons emitted.

77. The threshold voltage of a silicon diode is 0.7 V. It is operated at this point by connecting the diode in series with a battery of V volt and a resistor of 1000Ω. Find the value of V when the current drawn is 15 mA.

SECTION - C

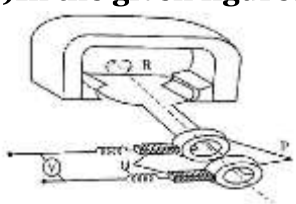
78. (a)A cell of e.m.f. E and internal resistance r is connected with a variable external resistance R and a voltmeter showing potential drop V across R. Obtain the relationship between V, E, R and r .
(b)Draw the shape of the graph showing the variation of terminal voltage V of the cell as a function of current I drawn from it. How one can determine the e.m.f. of the cell and its internal resistance from this graph?

79. (a)In a region of a uniform electric field $\vec{E}$, a negatively charged particle is moving with a constant velocity $\vec{v} = -v_0\hat{\imath}$ near a long straight conductor coinciding with XX' axis and carrying current I towards -X axis. The particle remains at a distance d from the conductor.
(i) Draw diagram showing direction of electric and magnetic fields.
(ii) What are the various forces acting on the charged particle?
(iii) Find the value of v_0 in terms of E, d and I.

OR

(b)Two infinitely long conductors kept along XX' and YY' axes are carrying current I_1 and I_2 along $-X$ axis and $-Y$ axis respectively. Find the magnitude and direction of the net magnetic field produced at point P(X, Y).

80. (a)State Lenz's law.
(b)In the given figure:



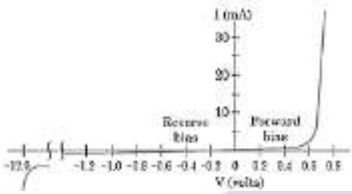
(i) Identify the machine.
(ii) Name the parts P and Q and R of the machine.
(iii) Give the polarities of the magnetic poles.
(iv) Write the two ways of increasing the output voltage.

81. (a)The electric field $\vec{E}$ of an electromagnetic wave propagating in north direction is oscillating in up and down direction. Describe the direction of magnetic field $\vec{B}$ of the wave.
(b)Are the wave length of radio waves and microwaves longer or shorter than those detectable by human eyes ?
(c)Write main use of each of the following in human life:
(i) Infrared waves
(ii) Gamma rays

82. **(a)When a parallel beam of light enters water surface obliquely at some angle, what is the effect on the width of the beam ?**
(b)With the help of a ray diagram, show that a straw appears bent when it is partly dipped in water and explain it.
(c)Explain the transmission of optical signal through an optical fibre by a diagram.

83. **(a) Show the variation of binding energy per nucleon with mass number. Write the significance of the binding energy curve.**
(b) Two nuclei with lower binding energy per nucleon form a nuclei with more binding energy per nucleon.
(i) What type of nuclear reaction is it?
(ii) Whether the total mass of nuclei increases, decreases or remains unchanged?
(iii) Does the process require energy or produce energy ?

84. **(a)What are majority and minority charge carriers in an extrinsic semiconductor?**
(b)A p-n junction is forward biased. Describe the movement of the charge carriers which produce current in it.
(c)The graph shows the variation of current with voltage for a p-n junction diode.



Estimate the dynamic resistance of diode at $V = -0.6$ volt.

SECTION-D

Question numbers 29 and 30 are case study based questions. Read the following paragraphs and answer the questions that follow.

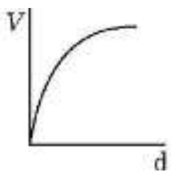
85. **A parallel plate capacitor has two parallel plates which are separated by an insulating medium like air, mica, etc. When the plates are connected to the terminals of a battery, they get equal and opposite charges and an electric field is set up in between them. This electric field between the two plates depends upon the potential difference applied, the separation of the plates and nature of the medium between the plates. $4 \times 1 =$**

(i) The electric field between the plates of a parallel plate capacitor is E . Now the separation between the plates is doubled and simultaneously the applied potential difference between the plates is reduced to half of its initial value. The new value of the electric field between the plates will be:

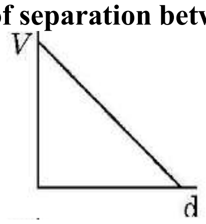
(a)E (b)2 E

(c)$\frac{E}{4}$ (d)$\frac{E}{2}$

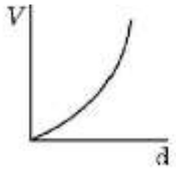
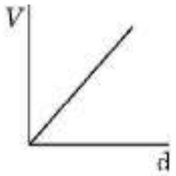
(ii) A constant electric field is to be maintained between the two plates of a capacitor whose separation d changes with time. Which of the graphs correctly depict the potential difference (V) to be applied between the plates as a function of separation between the plates (d)to maintain the constant electric field ?

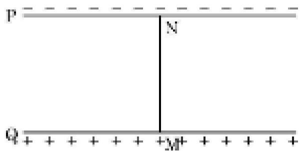


(a)

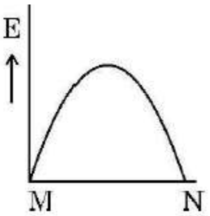
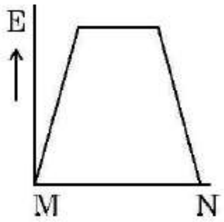


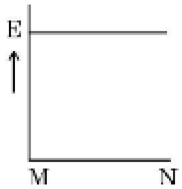
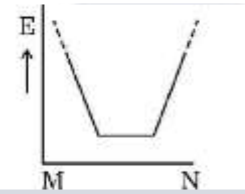
(b)

(c)  (d) 

(iii) 

In the above figure P, Q are the two parallel plates of a capacitor. Plate Q is at positive potential with respect to plate P. MN is an imaginary line drawn perpendicular to the plates. Which of the graphs shows correctly the variations of the magnitude of electric field strength E along the line MN?

(a)  (b) 

(c)  (d) 

(iv) Three parallel plates are placed above each other with equal displacement $\vec{d}$ between neighbouring plates. The electric field between the first pair of the plates is $\vec{E}_1$ and the electric field between the second pair of the plates is $\vec{E}_2$. The potential difference between the third and the first plate is -

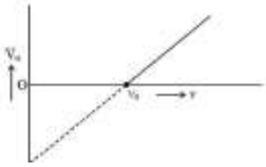
(a)$(\vec{E}_1+\vec{E}_2)\cdot\vec{d}$ (b)$(\vec{E}_1-\vec{E}_2)\cdot\vec{d}$
(c)$(\vec{E}_2-\vec{E}_1)\cdot\vec{d}$ (d)$\frac{d(E_1+E_2)}{2}$

OR

(iv) A material of dielectric constant K is filled in a parallel plate capacitor of capacitance C. The new value of its capacitance becomes

(a)C (b)$\frac{C}{K}$
(c)CK (d)$C\left(1+\frac{1}{K}\right)$

86. When a photon of suitable frequency is incident on a metal surface, photoelectron is emitted from it. If the frequency is below a threshold frequency (v_o) for the surface, no photoelectron is emitted. For a photon of frequency $v(v>v_o)$, the kinetic energy of the emitted photoelectrons is $h(v-v_0)$. The photocurrent can be stopped by applying a potential V_0 called 'stopping potential' on the anode. Thus maximum kinetic energy of photoelectrons $K_m=eV_o=h(v-v_o)$. The experimental graph between V_o and v for a metal is shown in figure. This is a straight line of slope m.



(i) The straight line graphs obtained for two metals
(a)coincide each other.
(b)are parallel to each other.
(c)are not parallel to each other and cross at a point on v-axis.
(d)are not parallel to each other and do not cross at a point on v axis.

(ii) The value of Planck's constant for this metal is

(a)$\frac{e}{m}$ (b)$\frac{1}{me}$
(c)me (d)$\frac{m}{e}$

(iii) The intercepts on v-axis and V_0-axis of the graph are respectively :
(a)$v_0, \frac{hv_0}{e}$ (b)v_0, hv_0
(c)$\frac{hv_0}{e}, v_0$ (d)hv_0, v_0

OR

(iii) When the wavelength of a photon is doubled, how many times its wave number and frequency become, respectively?
(a)$2, \frac{1}{2}$ (b)$\frac{1}{2}, \frac{1}{2}$
(c)$\frac{1}{2}, 2$ (d)2,2

(iv) The momentum of a photon is 5.0×10^{-29} kg. m/s. Ignoring relativistic effects (if any), the wavelength of the photon is
(a)1.33μ m (b)3.3μ m
(c)16.6μ m (d)13.3μ m

SECTION-E

87. (a)(i) A small conducting sphere A of radius r charged to a potential V , is enclosed by a spherical conducting shell B of radius R . If A and B are connected by a thin wire, calculate the final potential on sphere A and shell B.
(ii) Write two characteristics of equipotential surfaces. A uniform electric field of $50 \mathrm{NC}^{-1}$ is set up in a region along $+x$ axis. If the potential at the origin $(0,0)$ is 220 V , find the potential at a point (4 m, 3 m).

OR

(b)(i) What is difference between an open surface and a closed surface ? Draw elementary surface vector $d\vec{S}$ for a spherical surface S.
(ii) Define electric flux through a surface. Give the significance of a Gaussian surface. A charge outside a Gaussian surface does not contribute to total electric flux through the surface. Why?
(iii) A small spherical shell S_1 has point charges $q_1 = -3\mu C, q_2 = -2\mu C$ and $q_3 = 9\mu C$ inside it. This shell is enclosed by another big spherical shell S_2. A point charge Q is placed in between the two surfaces S_1 and S_2. If the electric flux through the surface S_2 is four times the flux through surface S_1, find charge Q.

88. (a)(i) What is the source of force acting on a current-carrying conductor placed in a magnetic field? Obtain the expression for force acting between two long straight parallel conductors carrying steady currents and hence define 'ampere'.
(ii) A point charge q is moving with velocity $\vec{v}$ in a uniform magnetic field $\vec{B}$. Find the work done by the magnetic force on the charge.
(iii) Explain the necessary conditions in which the trajectory of a charged particle is helical in a uniform magnetic field.

OR

(b)(i) A current carrying loop can be considered as a magnetic dipole placed along its axis. Explain.
(ii) Obtain the relation for magnetic dipole moment $\vec{M}$ of current carrying coil. Give the direction of $\vec{M}$.
(iii) A current carrying coil is placed in an external uniform magnetic field. The coil is free to turn in the magnetic field. What is the net force acting on the coil ? Obtain the orientation of the coil in stable equilibrium. Show that in this orientation the flux of the total field (field produced by the loop + external field) through the coil is maximum.

89. (a)(i) A thin pencil of length ($f/4$) is placed coinciding with the principal axis of a mirror of focal length f. The image of the pencil is real and enlarged, just touches the pencil. Calculate the magnification produced by the mirror.
(ii) A ray of light is incident on a refracting face AB of a prism ABC at an angle of 45°. The ray emerges from face AC and the angle of deviation is 15°. The angle of prism is 30°. Show that the emergent ray is normal to the face AC from which it emerges out. Find the refraction index of the material of the prism.

OR

(b)(i) Light consisting of two wavelengths 600 nm and 480 nm is used to obtain interference fringes in a double slit experiment. The screen is placed 1.0 m away from slits which are 1.0 nm apart.
(1) Calculate the distance of the third bright fringe on the screen from the central maximum for wavelength 600 nm .
(2) Find the least distance from the central maximum where the bright fringes due to both the wavelengths coincide.
(ii) (1) Draw the variation of intensity with angle of diffraction in single slit diffraction pattern. Write the expression for value of angle corresponding to zero intensity locations.
(2) In what way diffraction of light waves differs from diffraction of sound waves?

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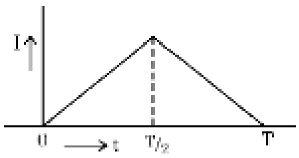
$h = 6.63 \times 10^{-34}$Js
$e = 1.6 \times 10^{-19}$C
$\mu_0 = 4\pi \times 10^{-7}$TmA^{-1}
$\varepsilon_0 = 8.854 \times 10^{-12}$C^2 N^{-1} m^{-2}
$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^{2}C^{-2}
Mass of electron $(m_e) = 9.1 \times 10^{-31}$ kg.
Mass of neutron $= 1.675 \times 10^{-27}$ kg.
Mass of proton $= 1.673 \times 10^{-27}$ kg.
Avogadro's number $= 6.023 \times 10^{23}$ per gram mole
Boltzmann's constant $= 1.38 \times 10^{-23}$JK^{-1}

SECTION-A

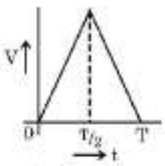
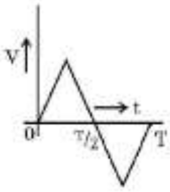
90. Two identical point charges are placed at the two vertices A and B of an equilateral triangle of side l. The magnitude of the electric field at the third vertex P is E. If a hollow conducting sphere of radius ($l/4$) is placed at P , the magnitude of the electric field at point P now becomes
(a) $>$ E (b) E
(c) $\frac{E}{2}$ (d) zero

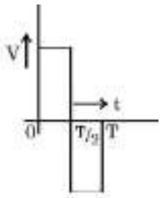
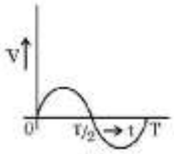
91. A battery of e.m.f. 12 V and internal resistance 0.5Ω is connected to a 9.5Ω resistor through a key. The ratio of potential difference between the two terminals of the battery, when the key is open to that when the key is closed, is
(a) 1.05 (b) 1
(c) 0.95 (d) 1.1

92. The alternating current I in an inductor is observed to vary with time t as shown in the graph for a cycle.



Which one of the following graphs is the correct representation of wave form of voltage V with time t ?

(a) 
(b) 

(c) 
(d) 

93. A diamagnetic substance is brought, one by one, near the north pole and the south pole of a bar magnet. It is

(a) repelled by north pole and attracted by south pole.
(b) attracted by north pole and repelled by south pole.
(c) attracted by north pole as well as by south pole.
(d) repelled by north pole as well as by south pole.

94. Two long solenoids of radii r_1 and $r_2(> r_1)$ and number of turns per unit length n_1 and n_2 respectively are co-axially wrapped one over the other. The ratio of self-inductance of inner solenoid to their mutual inductance is -

(a) $\frac{n_1}{n_2}$ (b) $\frac{n_2}{n_1}$
(c) $\frac{n_1 r_1^2}{n_2 r_2^2}$ (d) $\frac{n_2 r_1^2}{n_1 r_2^2}$

95. A 1 cm straight segment of a conductor carrying 1 A current in x direction lies symmetrically at origin of Cartesian coordinate system. The magnetic field due to this segment at point (1 m, 1 m, 0) is

(a) $1.0 \times 10^{-9}\hat{k}T$
(b) $-1.0 \times 10^{-9}\hat{k}T$
(c) $\frac{5.0}{\sqrt{2}} \times 10^{-10}\hat{k}T$
(d) $-\frac{5.0}{\sqrt{2}} \times 10^{-10}\hat{k}T$

96. A coil of an ac generator, having 100 turns and area $0.1\ m^2$ each, rotates at half a rotation per second in a magnetic field of 0.02 T . The maximum emf generated in the coil is

(a) 0.31 V (b) 0.20 V
(c) 0.63 V (d) 0.10 V

97. Atomic spectral emission lines of hydrogen atom are incident on a zinc surface. The lines which can emit photoelectrons from the surface are members of

(a) Balmer series
(b) Paschen series
(c) Lyman series
(d) Neither Balmer, nor Paschen nor Lyman series

98. The focal length of a concave mirror in air is f. When the mirror is immersed in a liquid of refractive index $\frac{5}{3}$, its focal length will become

(a) $\frac{5}{3}$f (b) $\frac{3}{5}$f

(c) $\frac{2}{3}$f (d) f

99. Which one of the following statements is correct?

Electric field due to static charges is

(a) conservative and field lines do not form closed loops.

(b) conservative and field lines form closed loops.

(c) non-conservative and field lines do not form closed loops.

(d) non-conservative and field lines form closed loops.

100. When the resistance measured between p and n ends of a $p-n$ junction diode is high, it can act as a/an -

(a) resistor (b) inductor

(c) capacitor (d) switch

101. The energy of an electron in a hydrogen atom in ground state is -13.6 eV. Its energy in an orbit corresponding to quantum number n is -0.544 eV. The value of n is

(a) 2 (b) 3

(c) 4 (d) 5

For Questions 13 to 16, two statements are given - one labelled Assertion (A) and other labelled Reason (R). Select the correct answer to these questions from the codes (A), (B), (C) and (D) as given below :

(A) If both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).

(B) If both Assertion (A) and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).

(C) If Assertion (A) is true but Reason (R) is false.

(D) If both Assertion (A) and Reason (R) are false.

102. Assertion (A): Out of Infrared and radio waves, the radio waves show more diffraction effect.

Reason (R): Radio waves have greater frequency than infrared waves.

103. Assertion (A): In an ideal step-down transformer, the electrical energy is not lost.

Reason (R): In a step-down transformer, voltage decreases but the current increases.

104. Assertion (A) : In Bohr model of hydrogen atom, the angular momentum of an electron in n^{th} orbit is proportional to the square root of its orbit radius r_n.

Reason (R) : According to Bohr model, electron can jump to its nearest orbits only.

105. Assertion (A): In a semiconductor diode the thickness of depletion layer is not fixed.

Reason (R): Thickness of depletion layer in a semiconductor device depends upon many factors such as biasing of the semiconductor.

SECTION - B

106. The threshold voltage of a silicon diode is 0.7 V. It is operated at this point by connecting the diode in series with a battery of V volt and a resistor of 1000Ω. Find the value of V when the current drawn is 15 mA.

107. Show the refraction of light wave at a plane interface using Huygens' principle and prove Snell's law.

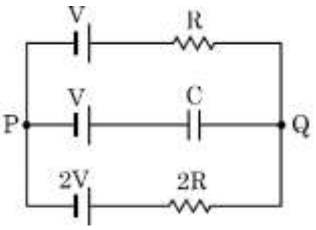
108. Two convex lenses A and B, each of focal length 10.0 cm, are mounted on an optical bench at 50.0 cm and 70.0 cm respectively. An object is mounted at 20.0 cm. Find the nature and position of the final image formed by the combination.

109. Radiations of two frequencies are incident on a metal surface of work function 2.0 eV one by one. The energies of their photons are 2.5 eV and 4.5 eV respectively. Find the ratio of the maximum speed of the electrons emitted in the two cases.

110. (a) Two wires of the same material and the same radius have their lengths in the ratio 2: 3. They are connected in parallel to a battery which supplies a current of 15 A. Find the current through the wires.

OR

(b) In the circuit three ideal cells of e.m.f. V, V and 2 V are connected to a resistor of resistance R, a capacitor of capacitance C and another resistor of resistance $2R$ as shown in figure. In the steady state find (i) the potential difference between P and Q and (ii) potential difference across capacitor C.



SECTION - C

111. **(a) Define resistivity of a conductor. Discuss its dependence on temperature of the conductor and draw a plot of resistivity of copper as a function of temperature.**

(b) (i) "A low voltage battery from which high current is required must have low internal resistance." Justify.

(ii) "A high voltage battery must have a large internal resistance." Justify.

112. **(a) When a parallel beam of light enters water surface obliquely at some angle, what is the effect on the width of the beam ?**

(b) With the help of a ray diagram, show that a straw appears bent when it is partly dipped in water and explain it.

(c) Explain the transmission of optical signal through an optical fibre by a diagram.

113. **Differentiate between the peak value and root mean square value of an alternating current. Derive the expression for the root mean square value of alternating current, in terms of its peak value.**

114. **(a) How is an electromagnetic wave produced?**

(b) An electromagnetic wave is travelling in vertically upward direction. At an instant, its electric field vector points in west direction. In which direction does the magnetic field vector point at that instant?

(c) Estimate the ratio of shortest wave length of radio waves to the longest wave length of gamma waves.

115. **(a) In a region of a uniform electric field $\vec{E}$, a negatively charged particle is moving with a constant velocity $\vec{v} = -v_0\hat{\imath}$ near a long straight conductor coinciding with XX′ axis and carrying current I towards -X axis. The particle remains at a distance d from the conductor.**

(i) Draw diagram showing direction of electric and magnetic fields.

(ii) What are the various forces acting on the charged particle?

(iii) Find the value of v_0 in terms of E, d and I .

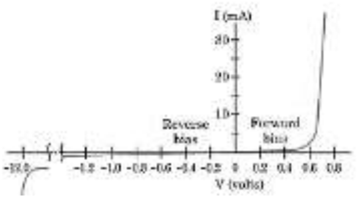
OR

(b) Two infinitely long conductors kept along XX′ and YY′ axes are carrying current I_1 and I_2 along $-X$ axis and $-Y$ axis respectively. Find the magnitude and direction of the net magnetic field produced at point P(X, Y).

116. **(a) What are majority and minority charge carriers in an extrinsic semiconductor?**

(b) A p-n junction is forward biased. Describe the movement of the charge carriers which produce current in it.

(c) The graph shows the variation of current with voltage for a p-n junction diode.



Estimate the dynamic resistance of diode at $V = -0.6$ volt.

117. **(a) Show the variation of binding energy per nucleon with mass number. Write the significance of the binding energy curve.**

(b) Two nuclei with lower binding energy per nucleon form a nuclei with more binding energy per nucleon.

(i) What type of nuclear reaction is it?

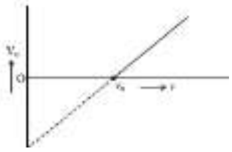
(ii) Whether the total mass of nuclei increases, decreases or remains unchanged ?

(iii) Does the process require energy or produce energy?

SECTION-D

Question numbers 29 and 30 are case study based questions. Read the following paragraphs and answer the questions that follow.

118. When a photon of suitable frequency is incident on a metal surface, photoelectron is emitted from it. If the frequency is below a threshold frequency (v_o) for the surface, no photoelectron is emitted. For a photon of frequency $v(v > v_o)$, the kinetic energy of the emitted photoelectrons is $h(v - v_o)$. The photocurrent can be stopped by applying a potential V_o called 'stopping potential' on the anode. Thus maximum kinetic energy of photoelectrons $K_m = eV_o = h(v - v_o)$. The experimental graph between V_o and v for a metal is shown in figure. This is a straight line of slope m.



(i) The straight line graphs obtained for two metals

(a) coincide each other.

(b) are parallel to each other.

(c) are not parallel to each other and cross at a point on v-axis.

(d) are not parallel to each other and do not cross at a point on v-axis.

(ii) The value of Planck's constant for this metal is

(a) $\frac{e}{m}$ (b) $\frac{1}{me}$

(c) me (d) $\frac{m}{e}$

(iii) The intercepts on v-axis and V_0-axis of the graph are respectively :

(a) $v_0, \frac{hv_0}{e}$ (b) v_0, hv_0

(c) $\frac{hv_0}{e}, v_0$ (d) hv_0, v_0

OR

(iii) When the wavelength of a photon is doubled, how many times its wave number and frequency become, respectively?

(a) $2, \frac{1}{2}$ (b) $\frac{1}{2}, \frac{1}{2}$

(c) $\frac{1}{2}, 2$ (d) 2,2

(iv) The momentum of a photon is 5.0×10^{-29} kg. m/s. Ignoring relativistic effects (if any), the wavelength of the photon is

(a) 1.33μ m(b) 3.3μ m

(c) 16.6μ m(d) 13.3μ m

119. A parallel plate capacitor has two parallel plates which are separated by an insulating medium like air, mica, etc. When the plates are connected to the terminals of a battery, they get equal and opposite charges and an electric field is set up in between them. This electric field between the two plates depends upon the potential difference applied, the separation of the plates and nature of the medium between the plates.

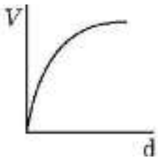
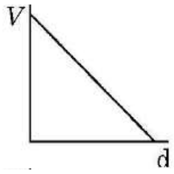
(i) The electric field between the plates of a parallel plate capacitor is E . Now the separation between the plates is doubled and simultaneously the applied potential difference between the plates is reduced to half of its initial value. The new value of the electric field between the plates will be:

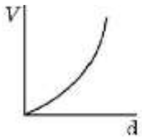
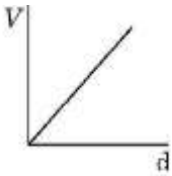
(a)E (b)2 E

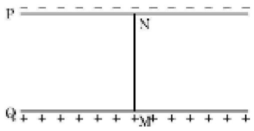
(c)$\frac{E}{4}$ (d)$\frac{E}{2}$

(ii) A constant electric field is to be maintained between the two plates of a capacitor whose separation d changes with time. Which of the graphs correctly depict the potential

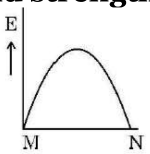
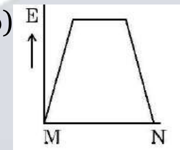
difference (V) to be applied between the plates as a function of separation between the plates (d)to maintain the constant electric field ?

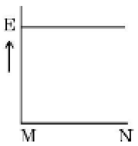
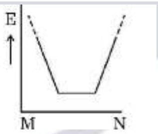
(a)  (b) 

(c)  (d) 

(iii) 

In the above figure P, Q are the two parallel plates of a capacitor. Plate Q is at positive potential with respect to plate P. MN is an imaginary line drawn perpendicular to the plates. Which of the graphs shows correctly the variations of the magnitude of electric field strength E along the line MN?

(a)  (b) 

(c)  (d) 

(iv) Three parallel plates are placed above each other with equal displacement $\vec{d}$ between neighbouring plates. The electric field between the first pair of the plates is $\vec{E}_1$ and the electric field between the second pair of the plates is $\vec{E}_2$. The potential difference between the third and the first plate is -

(a)$(\vec{E}_1 + \vec{E}_2) \cdot \vec{d}$ (b)$(\vec{E}_1 - \vec{E}_2) \cdot \vec{d}$

(c)$(\vec{E}_2 - \vec{E}_1) \cdot \vec{d}$ (d)$\frac{d(E_1+E_2)}{2}$

OR

(iv) A material of dielectric constant K is filled in a parallel plate capacitor of capacitance C. The new value of its capacitance becomes

(a)C (b)$\frac{C}{K}$

(c)CK (d)$C\left(1+\frac{1}{K}\right)$

SECTION-E

120. **(a) (i) A thin pencil of length ($f/4$) is placed coinciding with the principal axis of a mirror of focal length f. The image of the pencil is real and enlarged, just touches the pencil. Calculate the magnification produced by the mirror.**

(ii) A ray of light is incident on a refracting face AB of a prism ABC at an angle of 45°. The ray emerges from face AC and the angle of deviation is 15°. The angle of prism is 30°. Show that the emergent ray is normal to the face AC from which it emerges out. Find the refraction index of the material of the prism.

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(b) (i) Light consisting of two wavelengths 600 nm and 480 nm is used to obtain interference fringes in a double slit experiment. The screen is placed 1.0 m away from slits which are 1.0 nm apart.

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(ii) Write two characteristics of equipotential surfaces. A uniform electric field of $50 NC^{-1}$ is set up in a region along $+x$ axis. If the potential at the origin (0,0) is 220 V, find the potential at a point $(4\text{ m}, 3\text{ m})$.

OR

(b) (i) What is difference between an open surface and a closed surface? Draw elementary surface vector $d\vec{S}$ for a spherical surface S.
(ii) Define electric flux through a surface. Give the significance of a Gaussian surface. A charge outside a Gaussian surface does not contribute to total electric flux through the surface. Why?
(iii) A small spherical shell S_1 has point charges $q_1 = -3\mu C, q_2 = -2\mu C$ and $q_3 = 9\mu C$ inside it. This shell is enclosed by another big spherical shell S_2. A point charge Q is placed in between the two surfaces S_1 and S_2. If the electric flux through the surface S_2 is four times the flux through surface S_1, find charge Q.

122. (a) (i) What is the source of force acting on a current-carrying conductor placed in a magnetic field? Obtain the expression for force acting between two long straight parallel conductors carrying steady currents and hence define 'ampere'.
(ii) A point charge q is moving with velocity $\vec{v}$ in a uniform magnetic field $\vec{B}$. Find the work done by the magnetic force on the charge.
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(b) (i) A current carrying loop can be considered as a magnetic dipole placed along its axis. Explain.
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$c = 3 \times 10^8 \text{ m/s}$
$h = 6.63 \times 10^{-34} Js$

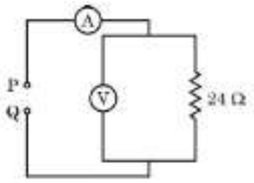
$e = 1.6 \times 10^{-19} C$
$\mu_0 = 4\pi \times 10^{-7} TmA^{-1}$
$\varepsilon_0 = 8.854 \times 10^{-12} C^2\ N^{-1}\ m^{-2}$
$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ N\ m^2 C^{-2}$
Mass of electron $(m_e) = 9.1 \times 10^{-31}$ kg.
Mass of neutron $= 1.675 \times 10^{-27}$ kg.
Mass of proton $= 1.673 \times 10^{-27}$ kg.
Avogadro's number $= 6.023 \times 10^{23}$ per gram mole
Boltzmann's constant $= 1.38 \times 10^{-23} JK^{-1}$

SECTION-A

123. Consider two identical dipoles D_1 and D_2. Charges $-q$ and q of dipole D_1 are located at $(0,0)$ and $(a,0)$ and that of dipole D_2 at $(0,a)$ and $(0,2a)$ in x-y plane, respectively. The net dipole moment of the system is

(a)$qa(\hat{\imath}+\hat{\jmath})$ (b)$-qa(\hat{\imath}+\hat{\jmath})$
(c)$qa(\hat{\imath}-\hat{\jmath})$ (d)$-qa(\hat{\imath}-\hat{\jmath})$

124. Which pair of readings of ideal voltmeter and ideal ammeter in the given circuit is possible when a suitable power source of 3Ω internal resistance is connected between P and Q?



(a)12.0 V, 2.0 A (b)2.0 V, 0.5 A
(c)6.0 V, 2.0 A (d)12 V, 0.5 A

125. Consider two long co-axial solenoids S_1 and S_2, each of length $l(\gg r_2)$ and of radius r_1 and $r_2 (r_2 > r_1)$. The number of turns per unit length are n_1 and n_2 respectively. Derive an expression for mutual inductance M_{12} of solenoid S_1 with respect to solenoid S_2. Show that $M_{21} = M_{12}$.

126. (a)A parallel plate capacitor is charged by an ac source. Show that the sum of conduction current (I_c) and the displacement current (I_d) has the same value at all points of the circuit.

(b)In case (a)above, is Kirchhoff's first rule (junction rule) valid at each plate of the capacitor? Explain.

127. (a)Draw a plot of frequency v of incident radiations as a function of stopping potential V_0 for a given photo emissive material. What information can be obtained from the value of the intercept on the stopping potential axis ?

(b)Calculate: (i) the momentum and (ii) de Broglie wavelength, of an electron with kinetic energy of 80 eV .

128. (a)Draw circuit arrangement for studying V-I characteristics of a p-n junction diode.

(b)Show the shape of the characteristics of a diode.

(c)Mention two information that you can get from these characteristics.

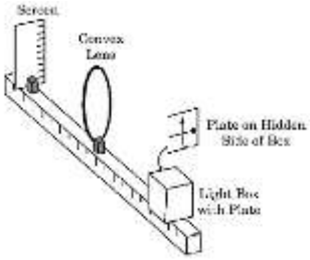
129. (a) Define 'Mass defect' and 'Binding energy' of a nucleus. Describe 'Fission process' on the basis of binding energy per nucleon.

(b)A deuteron contains a proton and a neutron and has a mass of 2.013553 u . Calculate the mass defect for it in u and its energy equivalence in MeV. ($m_p = 1.007277u, m_n = 1.008665u, 1u = 931.5 MeV/c^2$)

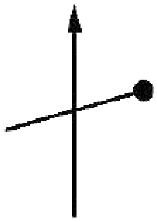
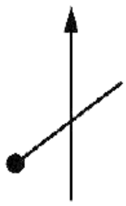
SECTION-D

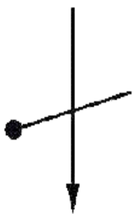
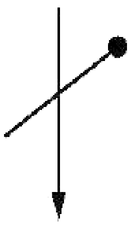
Question numbers 29 and 30 are case study based questions. Read the following paragraphs and answer the questions that follow.

130. A thin lens is a transparent optical medium bounded by two surfaces, at least one of which should be spherical. Applying the formula for image formation by a single spherical surface successively at the two surfaces of a lens, one can obtain the 'lens maker formula' and then the 'lens formula'. A lens has two foci - called 'first focal point' and 'second focal point' of the lens, one on each side.



(i)
Consider the arrangement shown in figure. A black vertical arrow and a horizontal thick line with a ball are painted on a glass plate. It serves as the object. When the plate is illuminated, its real image is formed on the screen.
Which of the following correctly represents the image formed on the screen?


(a)

(b)


(c)

(d)

(ii) Which of the following statements is incorrect?
(a)For a convex mirror magnification is always negative.
(b)For all virtual images formed by a mirror magnification is positive.
(c)For a concave lens magnification is always positive.
(d)For real and inverted images, magnification is always negative.

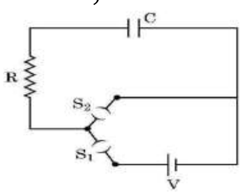
(iii) A convex lens of focal length ' f ' is cut into two equal parts perpendicular to the principal axis. The focal length of each part will be :
(a)f (b)2 f
(c)$\frac{f}{2}$ (d)$\frac{f}{4}$

OR

(iii) If an object in case (i) above is 20 cm from the lens and the screen is 50 cm away from the object, the focal length of the lens used is
(a)10 cm (b)12 cm
(c)16 cm (d)20 cm

(iv) The distance of an object from first focal point of a biconvex lens is X_1 and distance of the image from second focal point is X_2. The focal length of the lens is
(a)X_1X_2 (b)$\sqrt{X_1 + X_2}$
(c)$\sqrt{X_1X_2}$ (d)$\sqrt{\frac{X_2}{X_1}}$

131. A circuit consisting of a capacitor C, a resistor of resistance R and an ideal battery of emf V, as shown in figure is known as RC series circuit.



As soon as the circuit is completed by closing key S_1 (keeping S_2 open) charges begin to flow between the capacitor plates and the battery terminals. The charge on the capacitor

increases and consequently the potential difference $V_c(= q/C)$ across the capacitor also increases with time. When this potential difference equals the potential difference across the battery, the capacitor is fully charged ($Q = VC$). During this process of charging, the charge q on the capacitor changes with time t as $q = Q[1 - e^{-t/RC}]$

The charging current can be obtained by differentiating it and using $\frac{d}{dx}(e^{mx}) = me^{mx}$.

Consider the case when $R = 20 k\Omega, C = 500\mu$ F and $V = 10$ V.

(i) The final charge on the capacitor, when key S_1 is closed and S_2 is open, is

(a)$5\mu C$ (b)5 mC

(c)25 mC (d)0.1 C

(ii) For sufficient time the key S_1 is closed and S_2 is open. Now key S_2 is closed and S_1 is open. What is the final charge on the capacitor ?

(a)Zero (b)5 mC

(c)2.5 mC (d)$5\mu C$

(iii) The dimensional formula for RC is

(a)$[ML^2 T^{-3} A^{-2}]$ (b)$[M^0 L^0 T^{-1} A^0]$

(c)$[M^{-1} L^{-2} T^4 A^2]$ (d)$[M^0 L^0 T A^0]$

(iv) The key S_1 is closed and S_2 is open. The value of current in the resistor after 5 seconds, is

(a)$\frac{1}{2\sqrt{e}}$ mA (b)$\sqrt{e}$mA

(c)$\frac{1}{\sqrt{e}}$ mA (d)$\frac{1}{2e}$ mA

OR

(iv) The key S_1 is closed and S_2 is open. The initial value of charging current in the resistor, is

(a)5 mA (b)0.5 mA

(c)2 mA (d)1 mA

132. **(a)(i)(1) What are coherent sources ? Why are they necessary for observing a sustained interference pattern ?**

Lights from two independent sources are not coherent. Explain.

(ii) Two slits 0.1 mm apart are arranged 1.20 m from a screen. Light of wavelength 600 nm from a distant source is incident on the slits.

(1) How far apart will adjacent bright interference fringes be on the screen ?

(2) Find the angular width (in degree) of the first bright fringe.

OR

(b)(I)Define a wavefront . An incident plane wave falls on a convex lens and gets refracted through it Draw a diagram to show the incident and refracted wavefront. (II)A beam of light coming from a distant source is refracted by a spherical glass ball(refractive index 1.5) of radius 15 cm . Draw the ray diagram and obtain the position of the final image formed.

133. **(a) (i) Two point charges $5\mu C$ and $-1\mu C$ are placed at points (-3 cm , 0,0) and (3 cm, 0, 0) respectively. An external electric field $\vec{E} = \frac{A}{r^2}\hat{r}$ where $A = 3 \times 10^5$Vm is switched on in the region.**

Calculate the change in electrostatic energy of the system due to the electric field.

(ii) A system of two conductors is placed in air and they have net charge of $+80\mu C$ and $-80\mu C$ which causes a potential difference of 16 V between them.

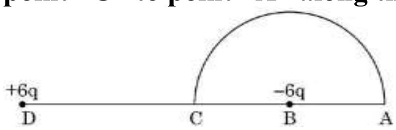
(1) Find the capacitance of the system.

(2) If the air between the capacitor is replaced by a dielectric medium of dielectric constant 3 , what will be the potential difference between the two conductors?

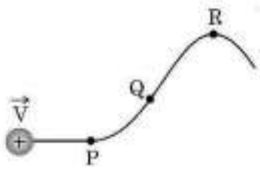
(3) If the charges on two conductors are changed to $+160\mu C$ and $-160\mu C$, will the capacitance of the system change ? Give reason for your answer.

OR

(b)(i) Consider three metal spherical shells A, B and C, each of radius R. Each shell is having a concentric metal ball of radius R/10. The spherical shells A, B and C are given charges $+6q, -4q$, and $14q$ respectively. Their inner metal balls are also given charges $-2q, +8q$ and $-10q$ respectively. Compare the magnitude of the electric fields due to shells A, B and C at a distance $3R$ from their centres.
(ii) A charge $-6\mu C$ is placed at the centre B of a semicircle of radius 5 cm , as shown in the figure. An equal and opposite charge is placed at point D at a distance of 10 cm from B . A charge $+5\mu C$ is moved from point ' C ' to point ' A ' along the circumference. Calculate the work done on the charge.



134. **(a)(i)A proton moving with velocity $\vec{V}$ in a non−uniform magnetic field traces a path as shown in the figure.**



The path followed by the proton is always in the plane of the paper. What is the direction of the magnetic field in the region near points P, Q and R ? What can you say about relative magnitude of magnetic fields at these points?
(ii) A current carrying circular loop of area A produces a magnetic field B at its centre. Show that the magnetic moment of the loop is $\frac{2BA}{\mu_0}\sqrt{\frac{A}{\pi}}$.

OR

(b)(i) Derive an expression for the torque acting on a rectangular current loop suspended in a uniform magnetic field.
(ii) A charged particle is moving in a circular path with velocity $\vec{V}$ in a uniform magnetic field $\vec{B}$ It is made to pass through a sheet of lead and as a consequence, it looses one half of its kinetic energy without change in its direction . How will (1) the radius of its path (2) its time period of revolution change ?

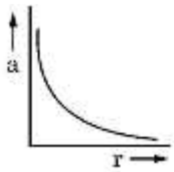
General Instructions:

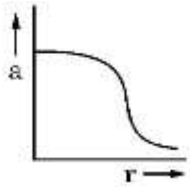
Read the following instructions very carefully and follow them :
(i) This question paper contains 33 questions. All questions are compulsory.
(ii) Question paper is divided into FIVE sections - Sections A, B, C, D and E.
(iii) In Section A: Question numbers 1 to 16 are Multiple Choice (MCQ) type questions. Each question carries 1 mark.
(iv) In Section B: Question numbers 17 to 21 are Very Short Answer (VSA) type questions. Each question carries 2 marks.
(v) In Section C: Question numbers 22 to 28 are Short Answer (SA) type questions. Each question carries 3 marks.
(vi) In Section D: Question numbers 29 & 30 are Case Study-Based questions. Each question carries 4 marks.
(vii) In Section E: Question numbers 31 to 33 are Long Answer (LA) type questions. Each question carries 5 marks.
(viii) There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the Sections except Section A.
(ix) Kindly note that there is a separate question paper for Visually Impaired candidates.
(x) Use of calculators is NOT allowed.
You may use the following values of physical constants wherever necessary:
$c = 3 \times 10^8$ m/s
$h = 6.63 \times 10^{-34}$Js
$e = 1.6 \times 10^{-19}$C
$\mu_0 = 4\pi \times 10^{-7}$TmA^{-1}
$\varepsilon_0 = 8.854 \times 10^{-12}$C^2 N^{-1} m^{-2}

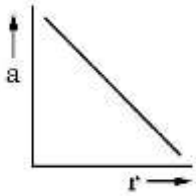
$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \text{ N m}^2\text{C}^{-2}$
Mass of electron $(m_e) = 9.1 \times 10^{-31}$ kg.
Mass of neutron $= 1.675 \times 10^{-27}$ kg.
Mass of proton $= 1.673 \times 10^{-27}$ kg.
Avogadro's number $= 6.023 \times 10^{23}$ per gram mole
Boltzmann's constant $= 1.38 \times 10^{-23} \text{JK}^{-1}$

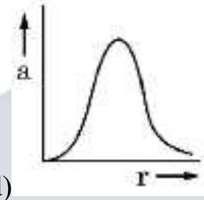
SECTION – A

135. A charge Q is fixed in position. Another charge q is brought near charge Q and released from rest. Which of the following graphs is the correct representation of the acceleration of the charge q as a function of its distance r from charge Q ?

(a) 

(b) 

(c) 

(d) 

136. Two conductors A and B of the same material have their lengths in the ratio $1:2$ and radii in the ratio $2:3$. If they are connected in parallel across a battery, the ratio $\frac{v_A}{v_B}$ of the drift velocities of electrons in them will be -

(a) 2 (b) $\frac{1}{2}$
(c) $\frac{3}{2}$ (d) $\frac{8}{9}$

137. A 1 cm segment of a wire lying along x -axis carries current of 0.5 A along $+x$ direction. A magnetic field $\vec{B} = (0.4\text{mT})\hat{j} + (0.6\text{mT})\hat{k}$ is switched on, in the region. The force acting on the segment is

(a) $(2\hat{j} + 3\hat{k})$mN (b) $(-3\hat{j} + 2\hat{k})\mu$N
(c) $(6\hat{j} + 4\hat{k})$mN (d) $(-4\hat{j} + 6\hat{k})\mu$N

138. The ratio of the number of turns of the primary to the secondary coils in an ideal transformer is $20:1$. If 240 V ac is applied from a source to the primary coil of transformer and a 6.0Ω resistor is connected across the output terminals, then current drawn by the transformer from the source will be -

(a) 4.0 A (b) 3.8 A
(c) 0.97 A (d) 0.10 A

139. You are required to design an air-filled solenoid of inductance 0.016 H having a length 0.81 m and radius 0.02 m. The number of turns in the solenoid should be

(a) 2592 (b) 2866
(c) 2976 (d) 3140

140. A voltage $v = v_0 \sin \omega t$ applied to a circuit drives a current $i = i_0 \sin(\omega t + \phi)$ in the circuit. The average power consumed in the circuit over a cycle is

(a) Zero (b) $i_0 v_0 \cos\phi$
(c) $\frac{i_0 v_0}{2}$ (d) $\frac{i_0 v_0}{2}\cos\phi$

141. X-rays are more harmful to human beings than ultraviolet radiations because X-rays -

(a) have frequency lower than that of ultraviolet radiations.
(b) have wavelength smaller than that of ultraviolet radiations.

(c)move faster than ultraviolet radiations in air.
(d)are mechanical waves but ultraviolet radiations are electro-magnetic waves.

142. A point source is placed at the bottom of a tank containing a transparent liquid (refractive index n) to a depth H. The area of the surface of the liquid through which light from the source can emerge out is

(a)$\frac{\pi H^2}{(n-1)}$ (b)$\frac{\pi H^2}{(n^2-1)}$
(c)$\frac{\pi H^2}{\sqrt{n^2-1}}$ (d)$\frac{\pi H^2}{(n^2+1)}$

143. In a photoelectric experiment with a material of work function 2.1 eV, the stopping potential is found to be 2.5 V . The maximum kinetic energy of ejected photoelectrons is

(a)0.4 Ev (b)2.1 eV
(c)2.5 eV (d)4.6 eV

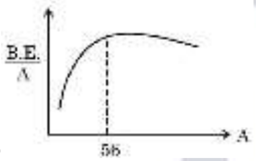
144. When a p-n junction diode is forward biased

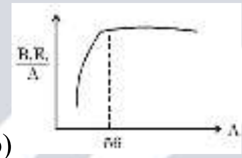
(a)the barrier height and the depletion layer width both increase.
(b)the barrier height increases and the depletion layer width decreases.
(c)the barrier height and the depletion layer width both decrease.
(d)the barrier height decreases and the depletion layer width increases.

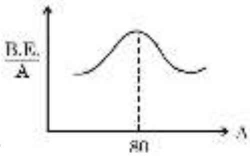
145. Let λ_e, λ_p and λ_d be the wavelengths associated with an electron, a proton and a deuteron, all moving with the same speed. Then the correct relation between them is

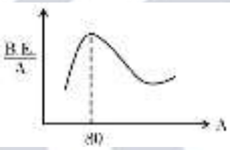
(a)$\lambda_d > \lambda_p > \lambda_e$ (b)$\lambda_e > \lambda_p > \lambda_d$
(c)$\lambda_p > \lambda_e > \lambda_d$ (d)$\lambda_e = \lambda_p = \lambda_d$

146. Which of the following figures correctly represent the shape of curve of binding energy per nucleon as a function of mass number?

(a) 

(b) 

(c) 

(d) 

Question numbers 13 to 16 are Assertion (a)and Reason (R) type questions. Two statements are given - one labelled Assertion (a)and the other labelled Reason (R). Select the correct answer from the codes (A), (B), (c)and (d)as given below.

(a)Both Assertion (a)and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(b)Both Assertion (a)and Reason (R) are true, but Reason (R) is not the correct explanation of Assertion (A).
(c)Assertion (a)is true, but Reason (R) is false.
(d)Assertion (a)is false and Reason (R) is also false.

147. Assertion (A): We cannot form a p-n junction diode by taking a slab of a p-type semiconductor and physically joining it to another slab of a n-type semiconductor.

Reason (R) : In a p-type semiconductor $\eta_e \gg \eta_h$ while in a n-type semiconductor $\eta_h \gg \eta_e$.

148. Assertion (A): The potential energy of an electron revolving in any stationary orbit in a hydrogen atom is positive.

Reason (R): The total energy of a charged particle is always positive.

149. Assertion (a): It is difficult to move a magnet into a coil of large number of turns when the circuit of the coil is closed.

Reason (R) : The direction of induced current in a coil with its circuit closed, due to motion of a magnet, is such that it opposes the cause.

150. Assertion (A): The deflection in a galvanometer is directly proportional to the current passing through it.

Reason (R): The coil of a galvanometer is suspended in a uniform radial magnetic field.

SECTION – B

151. n identical cells, each of e.m.f. E and internal resistance r , are connected in series. Later on it was found out that two cells ' X ' and ' Y ' are connected in reverse polarities. Calculate the potential difference across the cell ' X '.

152. (a)In a diffraction experiment, the slit is illuminated by light of wavelength 600 nm . The first minimum of the pattern falls at $\theta = 30^\circ$. Calculate the width of the slit.

OR

(b)In a Young's double-slit experiment, two light waves, each of intensity I_0, interfere at a point, having a path difference $\frac{\lambda}{8}$ on the screen. Find the intensity at this point.

153. A double convex lens of glass has both faces of the same radius of curvature 17 cm. Find its focal length if it is immersed in water. The refractive indices of glass and water are 1.5 and 1.33 respectively.

154. An electron in Bohr model of hydrogen atom makes a transition from energy level -1.51 eV to -3.40 eV. Calculate the change in the radius of its orbit. The radius of orbit of electron in its ground state is 0.53 Å.

155. A p-type Si semiconductor is made by doping an average of one dopant atom per 5×10^7 silicon atoms. If the number density of silicon atoms in the specimen is 5×10^{28} atoms m^{-3}, find the number of holes created per cubic centimetre in the specimen due to doping. Also give one example of such dopants.

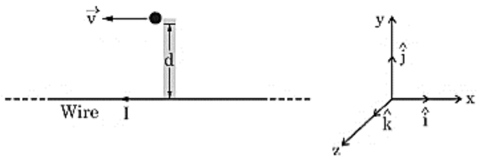
SECTION - C

156. (a)Two batteries of emf's 3 V & 6 V and internal resistances 0.2Ω & 0.4Ω are connected in parallel. This combination is connected to a 4Ω resistor. Find:
(i) the equivalent emf of the combination
(ii) the equivalent internal resistance of the combination
(iii) the current drawn from the combination

OR

(b)(i) A conductor of length l is connected across an ideal cell of emf E. Keeping the cell connected, the length of the conductor is increased to $2l$ by gradually stretching it. If R and R$'$ are initial and final values of resistance and v_d and $v_d{}'$ are initial and final values of drift velocity, find the relation between (i) R' and R and (ii) $v_d{}'$ and v_d.
(ii) When electrons drift in a conductor from lower to higher potential, does it mean that all the 'free electrons' of the conductor are moving in the same direction?

157. A particle of charge q is moving with a velocity $\vec{v}$ at a distance ' d ' from a long straight wire carrying a current ' I ' as shown in figure. At this instant, it is subjected to a uniform electric field $\vec{E}$ such that the particle keeps moving undeviated. In terms of unit vectors $\hat{\imath}, \hat{\jmath}$ and $\hat{k}$, find-



(a)the magnetic field $\vec{B}$,
(b)the magnetic force $\vec{F}_m$, and
(c)the electric field $\vec{E}$, acting on the charge.

158. An ac source of voltage $v = v_m \sin \omega t$ is connected to a series combination of LCR circuit. Draw the phasor diagram. Using it obtain an expression for the impedance of the circuit and the phase difference between applied voltage and the current.

159. (a)A parallel plate capacitor is charged by an ac source. Show that the sum of conduction current (I_c) and the displacement current (I_d) has the same value at all points of the circuit.
(b)In case (a)above, is Kirchhoffs first rule (junction rule) valid at each plate of the capacitor? Explain.

160. (a)Mention any three features of results of experiment on photoelectric effect which cannot be explained using the wave theory of light.

(b)In his experiment on photoelectric effect, Robert A. Millikan found the slope of the cut-off voltage versus frequency of incident light plot to be 4.12×10^{-15}Vs. Calculate the value of Planck's constant from it.

161. (a)Draw circuit arrangement for studying V-I characteristics of a p-n junction diode.

(b)Show the shape of the characteristics of a diode.

(c)Mention two information that you can get from these characteristics.

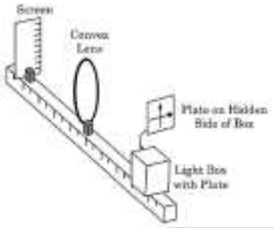
162. (a)Define 'Mass defect' and 'Binding energy' of a nucleus. Describe 'Fission process' on the basis of binding energy per nucleon.

(b)A deuteron contains a proton and a neutron and has a mass of 2.013553 u . Calculate the mass defect for it in u and its energy equivalence in MeV. ($m_p = 1.007277u, m_n = 1.008665u, 1u = 931.5MeV/c^2$)

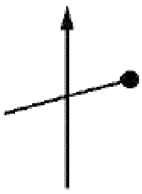
SECTION - D

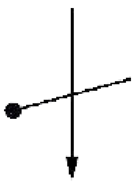
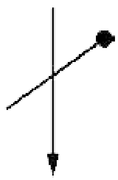
Question numbers 29 and 30 are case study based questions. Read the following paragraphs and answer the questions that follow.

163. A thin lens is a transparent optical medium bounded by two surfaces, at least one of which should be spherical. Applying the formula for image formation by a single spherical surface successively at the two surfaces of a lens, one can obtain the 'lens maker formula' and then the 'lens formula'. A lens has two foci - called 'first focal point' and 'second focal point' of the lens, one on each side.



(i)
Consider the arrangement shown in figure. A black vertical arrow and a horizontal thick line with a ball are painted on a glass plate. It serves as the object. When the plate is illuminated, its real image is formed on the screen.
Which of the following correctly represents the image formed on the screen?


(a)

(b)

(c)

(d)

(ii) Which of the following statements is incorrect?
(a)For a convex mirror magnification is always negative.
(b)For all virtual images formed by a mirror magnification is positive.
(c)For a concave lens magnification is always positive.
(d)For real and inverted images, magnification is always negative.

(iii) A convex lens of focal length ' f ' is cut into two equal parts perpendicular to the principal axis. The focal length of each part will be:
(a)f (b)2 f
(c)$\frac{f}{2}$ (d)$\frac{f}{4}$

OR

(iii) If an object in case (i) above is 20 cm from the lens and the screen is 50 cm away from the object, the focal length of the lens used is
(a)10 cm (b)12 cm
(c)16 cm (d)20 cm

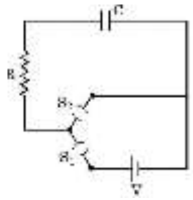
(iv) The distance of an object from first focal point of a biconvex lens is X_1 and distance of the image from

second focal point is X_2. The focal length of the lens is

(a)X_1X_2 (b)$\sqrt{X_1+X_2}$

(c)$\sqrt{X_1X_2}$ (d)$\sqrt{\frac{X_2}{X_1}}$

164. A circuit consisting of a capacitor C, a resistor of resistance R and an ideal battery of emf V, as shown in figure is known as RC series circuit.



As soon as the circuit is completed by closing key S_1 (keeping S_2 open) charges begin to flow between the capacitor plates and the battery terminals. The charge on the capacitor increases and consequently the potential difference $V_c(=q/C)$ across the capacitor also increases with time. When this potential difference equals the potential difference across the battery, the capacitor is fully charged ($Q = VC$). During this process of charging, the charge q on the capacitor changes with time t as $q = Q\left[1 - e^{-t/RC}\right]$

The charging current can be obtained by differentiating it and using $\frac{d}{dx}(e^{m\cdot x}) = me^{mx}$.

Consider the case when $R = 20k\Omega, C = 500\mu$ F and $V = 10$ V.

(i) The final charge on the capacitor, when key S_1 is closed and S_2 is open, is

(a)$5\mu C$ (b)5 mC

(c)25 mC (d)0.1 C

(ii) For sufficient time the key S_1 is closed and S_2 is open. Now key S_2 is closed and S_1 is open. What is the final charge on the capacitor ?

(a)Zero (b)5 mC

(c)2.5 mC (d)$5\mu C$

(iii) The dimensional formula for RC is

(a)$[ML^2\,T^{-3}\,A^{-2}]$ (b)$[M^0\,L^0\,T^{-1}\,A^0]$

(c)$[M^{-1}\,L^{-2}\,T^4\,A^2]$ (d)$[M^0\,L^0\,T\,A^0]$

(iv) The key S_1 is closed and S_2 is open. The value of current in the resistor after 5 seconds, is

(a)$\frac{1}{2\sqrt{e}}$ mA (b)$\sqrt{e}$mA

(c)$\frac{1}{\sqrt{e}}$ mA (d)$\frac{1}{2e}$ mA

OR

(iv) The key S_1 is closed and S_2 is open. The initial value of charging current in the resistor, is

(a)5 mA (b)0.5 mA

(c)2 mA (d)1 mA

165. (a)(i) (1) What are coherent sources ? Why are they necessary for observing a sustained interference pattern ?

(2) Lights from two independent sources are not coherent. Explain.

(ii) Two slits 0.1 mm apart are arranged 1.20 m from a screen. Light of wavelength 600 nm from a distant source is incident on the slits.

(1) How far apart will adjacent bright interference fringes be on the screen?

(2) Find the angular width (in degree) of the first bright fringe.

OR

(b)(i) Define a wavefront. An incident plane wave falls on a convex lens and gets refracted through it. Draw a diagram to show the incident and refracted wavefront.

(ii) A beam of light coming from a distant source is refracted by a spherical glass ball (refractive index 1.5) of radius 15 cm. Draw the ray diagram and obtain the position of the final image formed.

166. (a)(i) Two point charges $5\mu C$ and $-1\mu C$ are placed at points $(-3 \text{ cm}, 0, 0)$ and $(3 \text{ cm}, 0, 0)$ respectively. An external electric field $\vec{E} = \frac{A}{r^2}\hat{r}$ where $A = 3 \times 10^5 Vm$ is switched on in the region. Calculate the change in electrostatic energy of the system due to the electric field.

(ii) A system of two conductors is placed in air and they have net charge of $+80\mu C$ and $-80\mu C$ which causes a potential difference of 16 V between them.

(1) Find the capacitance of the system.

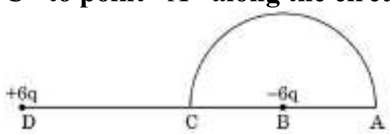
(2) If the air between the capacitor is replaced by a dielectric medium of dielectric constant 3 , what will be the potential difference between the two conductors?

(3) If the charges on two conductors are changed to $+160\mu C$ and $-160\mu C$, will the capacitance of the system change ? Give reason for your answer.

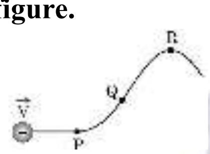
OR

(b)(i) Consider three metal spherical shells A, B and C, each of radius R . Each shell is having a concentric metal ball of radius R/10. The spherical shells A, B and C are given charges $+6q, -4q$, and $14q$ respectively. Their inner metal balls are also given charges $-2q, +8q$ and $-10q$ respectively. Compare the magnitude of the electric fields due to shells A, B and C at a distance 3 R from their centres.

(ii) A charge $-6\mu C$ is placed at the centre B of a semicircle of radius 5 cm, as shown in the figure. An equal and opposite charge is placed at point D at a distance of 10 cm from B. A charge $+5\mu C$ is moved from point ' C ' to point ' A ' along the circumference. Calculate the work done on the charge.



167. (a)(i) A proton moving with velocity $\vec{V}$ in a non-uniform magnetic field traces a path as shown in the figure.



The path followed by the proton is always in the plane of the paper. What is the direction of the magnetic field in the region near points P, Q and R? What can you say about relative magnitude of magnetic fields at these points?

(ii) A current carrying circular loop of area A produces a magnetic field B at its centre. Show that the magnetic moment of the loop is $\frac{2BA}{\mu_0}\sqrt{\frac{A}{\pi}}$.

OR

(b)(i) Derive an expression for the torque acting on a rectangular current loop suspended in a uniform magnetic field.

(ii) A charged particle is moving in a circular path with velocity $\vec{V}$ in a uniform magnetic field $\vec{B}$. It is made to pass through a sheet of lead and as a consequence, it looses one half of its kinetic energy without change in its direction. How will (1) the radius of its path (2) its time period of revolution change?

168. Which one of the following statements is correct?

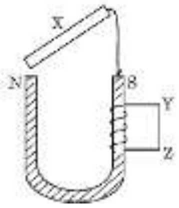
Electric field due to static charges is

(a)conservative and field lines do not form closed loops.
(b)conservative and field lines form closed loops.
(c)non-conservative and field lines do not form closed loops.
(d)non-conservative and field lines form closed loops.

169. A material is pushed out when placed in a uniform magnetic field. The material is

(a)non-magnetic (b)diamagnetic
(c)paramagnetic (d)ferromagnetic

170. A soft iron rod X is allowed to fall on the two poles of a U shaped permanent magnet as shown in figure. A coil is wrapped over one arm of the U shaped magnet.



During fall of the rod, the current in the coil will be

(a)clockwise current (b)anticlockwise current

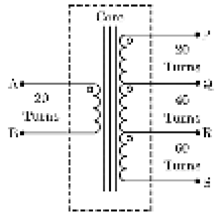
(c)alternating current (d)zero

171. A 1 cm straight segment of a conductor carrying 1 A current in x direction lies symmetrically at origin of Cartesian coordinate system. The magnetic field due to this segment at point ($1 \mathrm{~m}, 1 \mathrm{~m}, 0$) is

(a)$1.0 \times 10^{-9} \hat{k} \mathrm{T}$ (b)$-1.0 \times 10^{-9} \hat{k} \mathrm{T}$

(c)$\frac{5.0}{\sqrt{2}} \times 10^{-10} \hat{k} \mathrm{T}$ (d)$-\frac{5.0}{\sqrt{2}} \times 10^{-10} \hat{k} \mathrm{T}$

172. The number of turns between different pairs of output terminals are shown for a step-up transformer.

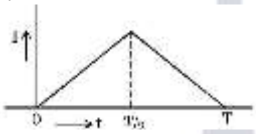


Input voltage of 20 V is applied between A and B. Between which two terminals will the output be 120 V?

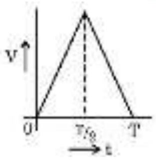
(a)P and Q (b)Q and S

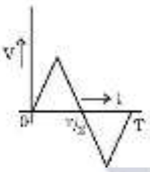
(c)P and R (d)P and S

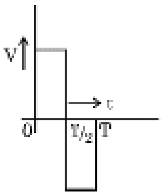
173. The alternating current I in an inductor is observed to vary with time t as shown in the graph for a cycle.

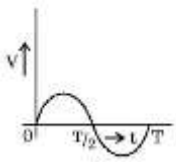


Which one of the following graphs is the correct representation of wave form of voltage V with time t ?


(a)


(b)


(c)


(d)

174. The plane face of a planoconvex lens is silvered. The refractive index of material and radius of curvature of the curved surface of the lens are n and R respectively. This lens will behave as a concave mirror of focal length

(a)$\frac{R}{n}$ (b)$\frac{R}{(n-1)}$

(c)nR (d)$\frac{R}{2(n-1)}$

175. When the resistance measured between p and n ends of a $p-n$ junction diode is high, it can act as a/an -

(a)resistor (b)inductor

(c)capacitor (d)switch

176. **Atomic spectral emission lines of hydrogen atom are incident on a zinc surface. The lines which can emit photoelectrons from the surface are members of**
(a)Balmer series
(b)Paschen series
(c)Lyman series
(d)Neither Balmer, nor Paschen nor Lyman series

177. **The energy of an electron in a hydrogen atom in ground state is -13.6 eV. Its energy in an orbit corresponding to quantum number n is -0.544 eV. The value of n is**
(a)2 (b)3
(c)4 (d)5

For Questions 13 to 16, two statements are given - one labelled Assertion (a)and other labelled Reason (R). Select the correct answer to these questions from the codes (A), (B), (c)and (d)as given below :
(a)If both Assertion (A)and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(b)If both Assertion (A)and Reason (R) are true but Reason (R) is not the correct explanation of Assertion (A).
(c)If Assertion (A)is true but Reason (R) is false.
(d)If both Assertion (A)and Reason (R) are false.

178. **Assertion (A):** In an ideal step-down transformer, the electrical energy is not lost.
Reason (R): In a step-down transformer, voltage decreases but the current increases.

179. **Assertion (A):** Out of Infrared and radio waves, the radio waves show more diffraction effect.
Reason (R): Radio waves have greater frequency than infrared waves.

180. **Assertion (A):** In a semiconductor diode the thickness of depletion layer is not fixed.
Reason (R): Thickness of depletion layer in a semiconductor device depends upon many factors such as biasing of the semiconductor.

181. **Assertion (A):** In Bohr model of hydrogen atom, the angular momentum of an electron in n^{th} orbit is proportional to the square root of its orbit radius r_n.
Reason (R) : According to Bohr model, electron can jump to its nearest orbits only.

SECTION - B

182. **The threshold voltage of a silicon diode is 0.7 V. It is operated at this point by connecting the diode in series with a battery of V volt and a resistor of 1000Ω. Find the value of V when the current drawn is 15 mA.**

183. **In a double slit experiment, it is observed that the angular width of one fringe formed on the screen is 0.2°. The wavelength of light used in the experiment is 500 nm. Calculate the separation of the two slits.**

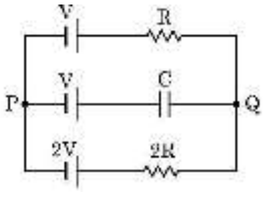
184. **A light beam converges at a point O. In the path of this beam, a concave lens of focal length 15 cm is placed at a distance of 10 cm before point O. The beam now converges at a point O'. Find the magnitude and the direction of shift OO'.**

185. **The threshold wavelength of a metal is 450 nm. Calculate (i) the work function of the metal in eV and (ii) the maximum energy of the ejected photoelectrons in eV by incident radiation of 250 nm.**

186. **(a)Two wires of the same material and the same radius have their lengths in the ratio 2: 3. They are connected in parallel to a battery which supplies a current of 15 A . Find the current through the wires.**

OR

(b)In the circuit three ideal cells of e.m.f. V, V and 2 V are connected to a resistor of resistance R, a capacitor of capacitance C and another resistor of resistance $2R$ as shown in figure. In the steady state find (i) the potential difference between P and Q and (ii) potential difference across capacitor C.



SECTION-C

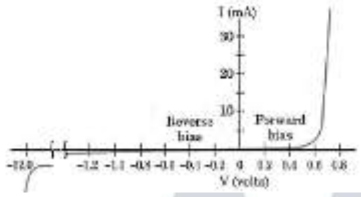
187. (a)Define Electrical conductivity. Obtain the expression of electrical conductivity of a conductor in terms of number density and relaxation time of free electrons.
(b)Explain qualitative change in resistivity of a conductor with temperature using expression obtained in (a).

188. (a)Show the variation of binding energy per nucleon with mass number. Write the significance of the binding energy curve.
(b)Two nuclei with lower binding energy per nucleon form a nuclei with more binding energy per nucleon.
(i) What type of nuclear reaction is it?
(ii) Whether the total mass of nuclei increases, decreases or remains unchanged?
(iii) Does the process require energy or produce energy?

189. (a) ac voltage of frequency ω is applied across a series LCR circuit. Draw the phasor diagram and obtain the impedance of the circuit.
(b) Discuss 'resonance' in a series LCR circuit and write the expression for resonant frequency.

190. (a)The amplitude of a light wave becomes n times. This results in intensity of the wave becoming m times. What is the relation between n and m?
(b)White light is incident on three identical surfaces - a black surface, a yellow surface and a white surface, one by one. For which surface, the pressure exerted on the surface by the incident light will be (i) maximum (ii) minimum ? Justify your answer.

191. (a)What are majority and minority charge carriers in an extrinsic semiconductor?
(b)A p-n junction is forward biased. Describe the movement of the charge carriers which produce current in it.
(c)The graph shows the variation of current with voltage for a p-n junction diode.



Estimate the dynamic resistance of diode at $V = -0.6$ volt.

192. (a)In a region of a uniform electric field $\vec{E}$, a negatively charged particle is moving with a constant velocity $\vec{v} = -v_0\hat{\imath}$ near a long straight conductor coinciding with XX′ axis and carrying current I towards -X axis. The particle remains at a distance d from the conductor.
(i) Draw diagram showing direction of electric and magnetic fields.
(ii) What are the various forces acting on the charged particle?
(iii) Find the value of v_0 in terms of E, d and I .

OR

(b)Two infinitely long conductors kept along XX′ and YY′ axes are carrying current I_1 and I_2 along $-X$ axis and $-Y$ axis respectively. Find the magnitude and direction of the net magnetic field produced at point P(X, Y).

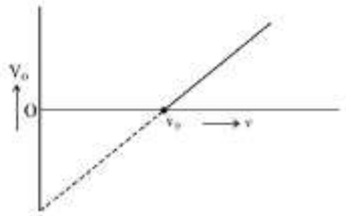
193. (a)When a parallel beam of light enters water surface obliquely at some angle, what is the effect on the width of the beam ?
(b)With the help of a ray diagram, show that a straw appears bent when it is partly dipped in water and explain it.
(c)Explain the transmission of optical signal through an optical fibre by a diagram.

SECTION - D

Question numbers 29 and 30 are case study based questions. Read the following paragraphs and answer the questions that follow.

194. When a photon of suitable frequency is incident on a metal surface, photoelectron is emitted from it. If the frequency is below a threshold frequency (ν_0) for the surface, no

photoelectron is emitted. For a photon of frequency $v(v > v_0)$, the kinetic energy of the emitted photoelectrons is $h(v - v_0)$. The photocurrent can be stopped by applying a potential V_0 called 'stopping potential' on the anode. Thus maximum kinetic energy of photoelectrons $K_m = eV_0 = h(v - v_0)$. The experimental graph between V_0 and v for a metal is shown in figure. This is a straight line of slope m.

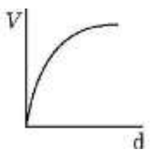
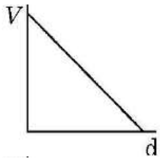
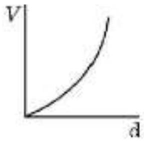
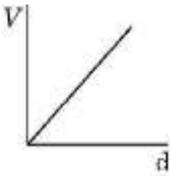


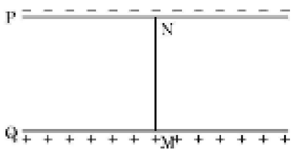
(i) The straight line graphs obtained for two metals
(a)coincide each other.
(b)are parallel to each other.
(c)are not parallel to each other and cross at a point on v-axis.
(d)are not parallel to each other and do not cross at a point on v-axis.
(ii) The value of Planck's constant for this metal is
(a)$\frac{e}{m}$ (b)$\frac{1}{me}$
(c)me (d)$\frac{m}{e}$
(iii) The intercepts on v-axis and V_0-axis of the graph are respectively :
(a)$v_0, \frac{hv_0}{e}$ (b)v_0, hv_0
(c)$\frac{hv_0}{e}, v_0$ (d)hv_0, v_0

OR

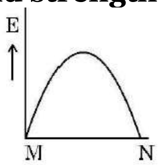
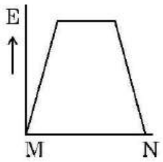
(iii) When the wavelength of a photon is doubled, how many times its wave number and frequency become, respectively?
(a)$2, \frac{1}{2}$ (b)$\frac{1}{2}, \frac{1}{2}$
(c)$\frac{1}{2}, 2$ (d)2,2
(iv) The momentum of a photon is 5.0×10^{-29} kg. m/s. Ignoring relativistic effects (if any), the wavelength of the photon is
(a)1.33μ m (b)3.3μ m
(c)16.6μ m (d)13.3μ m

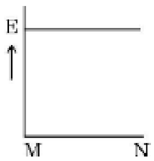
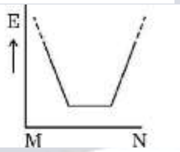
195. A parallel plate capacitor has two parallel plates which are separated by an insulating medium like air, mica, etc. When the plates are connected to the terminals of a battery, they get equal and opposite charges and an electric field is set up in between them. This electric field between the two plates depends upon the potential difference applied, the separation of the plates and nature of the medium between the plates.
(i) The electric field between the plates of a parallel plate capacitor is E . Now the separation between the plates is doubled and simultaneously the applied potential difference between the plates is reduced to half of its initial value. The new value of the electric field between the plates will be:
(a)E (b)2 E
(c)$\frac{E}{4}$ (d)$\frac{E}{2}$
(ii) A constant electric field is to be maintained between the two plates of a capacitor whose separation d changes with time. Which of the graphs correctly depict the potential difference (V) to be applied between the plates as a function of separation between the plates (d)to maintain the constant electric field?

(a)  (b) 
(c)  (d) 

(iii) 

In the above figure P, Q are the two parallel plates of a capacitor. Plate Q is at positive potential with respect to plate P. MN is an imaginary line drawn perpendicular to the plates. Which of the graphs shows correctly the variations of the magnitude of electric field strength E along the line MN?

(a)  (b) 

(c)  (d) 

(iv) Three parallel plates are placed above each other with equal displacement $\vec{d}$ between neighbouring plates. The electric field between the first pair of the plates is $\vec{E}_1$ and the electric field between the second pair of the plates is $\vec{E}_2$. The potential difference between the third and the first plate is -

(a)$(\vec{E}_1 + \vec{E}_2) \cdot \vec{d}$ (b)$(\vec{E}_1 - \vec{E}_2) \cdot \vec{d}$

(c)$(\vec{E}_2 - \vec{E}_1) \cdot \vec{d}$ (d)$\frac{d(E_1+E_2)}{2}$

OR

(iv) A material of dielectric constant K is filled in a parallel plate capacitor of capacitance C. The new value of its capacitance becomes

(a)C (b)$\frac{C}{K}$

(c)CK (d)$C\left(1+\frac{1}{K}\right)$

SECTION-E

196. (a)(i) What is the source of force acting on a current-carrying conductor placed in a magnetic field? Obtain the expression for force acting between two long straight parallel conductors carrying steady currents and hence define 'ampere'.

(ii) A point charge q is moving with velocity $\vec{v}$ in a uniform magnetic field $\vec{B}$. Find the work done by the magnetic force on the charge.

(iii) Explain the necessary conditions in which the trajectory of a charged particle is helical in a uniform magnetic field.

OR

(b)(i) A current carrying loop can be considered as a magnetic dipole placed along its axis. Explain.

(ii) Obtain the relation for magnetic dipole moment $\vec{M}$ of current carrying coil. Give the direction of $\vec{M}$.

(iii) A current carrying coil is placed in an external uniform magnetic field. The coil is free to turn in the magnetic field. What is the net force acting on the coil ? Obtain the orientation of the coil in stable

equilibrium. Show that in this orientation the flux of the total field (field produced by the loop + external field) through the coil is maximum.

197. (a)(i) A thin pencil of length ($f/4$) is placed coinciding with the principal axis of a mirror of focal length f. The image of the pencil is real and enlarged, just touches the pencil. Calculate the magnification produced by the mirror.

(ii) A ray of light is incident on a refracting face AB of a prism ABC at an angle of 45°. The ray emerges from face AC and the angle of deviation is 15°. The angle of prism is 30°. Show that the emergent ray is normal to the face AC from which it emerges out. Find the refraction index of the material of the prism.

OR

(b)(i) Light consisting of two wavelengths 600 nm and 480 nm is used to obtain interference fringes in a double slit experiment. The screen is placed 1.0 m away from slits which are 1.0 nm apart.

(1) Calculate the distance of the third bright fringe on the screen from the central maximum for wavelength 600 nm .

(2) Find the least distance from the central maximum where the bright fringes due to both the wavelengths coincide.

(ii) (1) Draw the variation of intensity with angle of diffraction in single slit diffraction pattern. Write the expression for value of angle corresponding to zero intensity locations.

(2) In what way diffraction of light waves differs from diffraction of sound waves?

198. (a)(i) A small conducting sphere A of radius r charged to a potential V, is enclosed by a spherical conducting shell B of radius R. If A and B are connected by a thin wire, calculate the final potential on sphere A and shell B.

(ii) Write two characteristics of equipotential surfaces. A uniform electric field of $50 NC^{-1}$ is set up in a region along $+x$ axis. If the potential at the origin (0,0) is 220 V, find the potential at a point $(4 \text{ m}, 3 \text{ m})$.

OR

(b)(i) What is difference between an open surface and a closed surface? Draw elementary surface vector $d\vec{S}$ for a spherical surface S.

(ii) Define electric flux through a surface. Give the significance of a Gaussian surface. A charge outside a Gaussian surface does not contribute to total electric flux through the surface. Why?

(iii) A small spherical shell S_1 has point charges $q_1 = -3\mu C, q_2 = -2\mu C$ and $q_3 = 9\mu C$ inside it. This shell is enclosed by another big spherical shell S_2. A point charge Q is placed in between the two surfaces S_1 and S_2. If the electric flux through the surface S_2 is four times the flux through surface S_1, find charge Q.

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You may use the following values of physical constants wherever necessary:

$c = 3 \times 10^8 \text{ m/s}$
$h = 6.63 \times 10^{-34} \text{Js}$
$e = 1.6 \times 10^{-19} \text{C}$
$\mu_0 = 4\pi \times 10^{-7} \text{TmA}^{-1}$

$\varepsilon_0 = 8.854 \times 10^{-12} C^2\ N^{-1}\ m^{-2}$

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ N\ m^2 C^{-2}$

Mass of electron $(m_e) = 9.1 \times 10^{-31}$ kg.

Mass of neutron $= 1.675 \times 10^{-27}$ kg.

Mass of proton $= 1.673 \times 10^{-27}$ kg.

Avogadro's number $= 6.023 \times 10^{23}$ per gram mole

Boltzmann's constant $= 1.38 \times 10^{-23} JK^{-1}$

SECTION-A

199. A body acquires charge 8.0×10^{-12}C. The mass of the body :

(a) increases by 4.5×10^{-7} kg

(b) decreases by 1.0×10^{-6} kg

(c) decreases by 4.55×10^{-28} kg

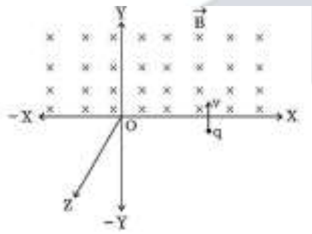
(d) increases by 9.1×10^{-28} kg

200. A current flows through a cylindrical conductor of radius R . The current density at a point in the conductor is $j = \alpha r$ (along its axis), here α is a constant and r is distance from the axis of the conductor. The current flowing through the portion of the conductor from $r = 0$ to $r = \frac{R}{2}$ is proportional to:

(a) R (b) R^2

(c) R^3 (d) R^4

201. A particle having charge $+q$ enters a uniform magnetic field $\vec{B}$ as shown in the figure. The particle will describe:



(a) a circular path in XZ plane

(b) a semicircular path in XY plane

(c) a helical path with its axis parallel to Y -axis

(d) a semicircular path in YZ plane

202. A bar magnet is initially at right angles to a uniform magnetic field. The magnet is rotated till the torque acting on it becomes one-half of its initial value. The angle through which the bar magnet is rotated is:

(a) 30° (b) 45°

(c) 60° (d) 75°

203. Which one out of the following materials is not paramagnetic?

(a) Aluminium (b) Sodium Chloride

(c) Calcium (d) Copper Chloride

204. An ammeter connected in series in an ac circuit reads 10 A. The maximum value of current at any instant in the circuit is :

(a) $10\sqrt{2}$ A (b) $\frac{10}{\sqrt{2}}$ A

(c) $\frac{10}{\pi}$ A (d) $\frac{10}{\sqrt{2}\pi}$ A

205. The amplitude of electric field in an electromagnetic wave in free space is $1000 Vm^{-1}$. The amplitude of the magnetic field in this electromagnetic wave is :

(a) 3.0×10^{-3} T (b) 3.33×10^{-8} T

(c) 3.0×10^{11} T (d) 3.33×10^{-6} T

206. The magnification produced by a spherical mirror is $-2 \cdot 0$. The mirror used and the nature of the image formed will be

(a) Convex and virtual
(b) Concave and real
(c) Concave and virtual
(d) Convex and real

207. Choose the correct statement :
(a) Photons of light show diffraction whereas electrons do not show diffraction.
(b) Electrons have momentum whereas photons do not have momentum.
(c) Photons of light and electrons both exhibit dual nature.
(d) All electromagnetic radiations do not have photons.

208. A beam of red light and a beam of blue light have equal intensities. Which of the following statements is true?
(a) The blue beam has more number of photons than the red beam.
(b) The red beam has more number of photons than the blue beam.
(c) Wavelength of red light is lesser than wavelength of blue light.
(d) The blue light beam has lesser energy per photon than that in the red light beam.

209. Which of the following is an electrical conductor at room temperature ?

(a) Sn	(b) Mica
(c) Si	(d) C

210. A long straight wire is held vertically and carries a steady current in upward direction. The shape of magnetic field lines produced by the current-carrying wire are :
(a) horizontal straight lines directed radially out from the wire.
(b) straight lines parallel to the current-carrying wire.
(c) concentric horizonal circles around the wire.
(d) coaxial helixes around the wire.

Questions number 13 to 16 are Assertion (A) and Reason (R) type questions. Two statements are given - one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (A), (B), (C) and (D) as given below.
(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).
(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).
(C) Assertion (A) is true, but Reason (R) is false.
(D) Both Assertion (A) and Reason (R) are false.

211. Assertion (A): n-type semiconductor is not negatively charged.
Reason (R): Neutral pentavalent impurity atom doped in intrinsic semiconductor (neutral) donates its fifth unpaired electron to the crystal lattice and becomes a positive donor.

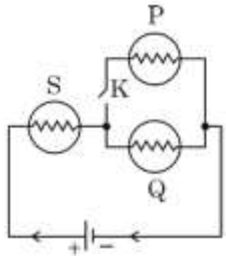
212. Assertion (A): A series LCR circuit behaves as a pure resistive circuit at resonance.
Reason (R): At resonance, $X_L = X_C$ gives $\omega = \frac{1}{\sqrt{LC}}$.

213. Assertion (A): In double slit experiment if one slit is closed, diffraction pattern due to the other slit will appear on the screen.
Reason (R): For interference, at least two waves are required.

214. Assertion (A): For monochromatic incident radiation, the emitted photoelectrons from a given metal have speed ranging from zero to a certain maximum value.
Reason (R): Each metal has a definite work function.

SECTION B

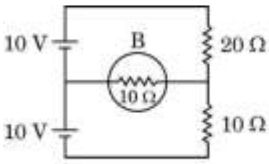
215. (a) In the given figure, three identical bulbs P, Q and S are connected to a battery.



(i) Compare the brightness of bulbs P and Q with that of bulb S when key K is closed.
(ii) Compare the brightness of the bulbs S and Q when the key K is opened.
Justify your answer in both cases.

OR

(b) Two cells of emf 10 V each, two resistors of 20Ω and 10Ω and a bulb B of 10Ω resistance are connected together as shown in the figure. Find the current that flows through the bulb.



216. Find the angle of diffraction (in degrees) for first secondary maximum of the pattern due to diffraction at a single slit. The width of the slit and wavelength of light used are 0.55 mm and 550 nm, respectively.

217. An equiconvex lens is made of glass of refractive index 1.55. If the focal length of the lens is 15.0 cm, calculate the radius of curvature of its surfaces.

218. Calculate the mass of an α-particle in atomic mass unit (u). Given, Mass of a normal helium atom $= 4.002603\mathrm{u}$

Mass of carbon atom $= 1.9926 \times 10^{-26}$ kg

219. In an intrinsic semiconductor, carrier's concentration is $5 \times 10^{8}\ \mathrm{m}^{-9}$. On doping with impurity atoms, the hole concentration becomes $8 \times 10^{12}\ \mathrm{m}^{-8}$.

(a) Identify (i) the type of dopant and (ii) the extrinsic semiconductor so formed.

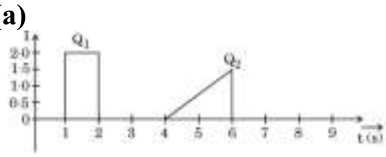
(b) Calculate the electron concentration in the extrinsic semiconductor.

SECTION C

220. (a) (i) Derive an expression for the resistivity of a conductor in terms of number density of free electrons and relaxation time.

(ii) The figure shows the plot of current through a cross-section of wire over two different time intervals. Compare the charges (Q_1 and Q_2) that pass through the cross-section during these time intervals.

(a)



OR

(b) (i) A battery of emf E and internal resistance r is connected to a variable external resistance R.

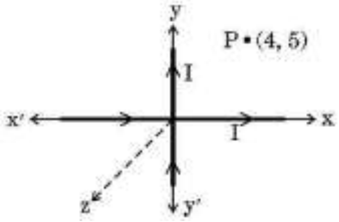
(I) Obtain the expression for current I in the circuit and the value of maximum current the battery can supply.

(II) Obtain the terminal voltage V across the battery and its maximum possible value.

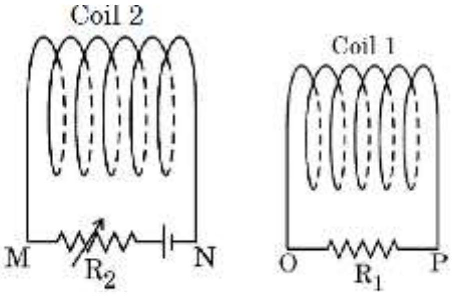
(ii) The above battery sends a current I_1 when $R = R_1$ and a current I_2 when $R = R_2$. Obtain the internal resistance of the battery in terms of I_1, I_2, R_1 and R_2.

221. (a) Write vector form of Biot-Savart law.

(b) Two insulated long straight wires, each carrying 2.0 A current are kept along xx' and yy' axis as shown in the figure. Find the magnitude and direction of resultant magnetic field at point $P(4\ \mathrm{m}, 5\ \mathrm{m})$.



222. Two coils ' 1 ' and ' 2 ' are placed close to each other as shown in the figure. Find the direction of induced current in coil ' 1 ' in each of the following situations, justifying your answers:



223. (a) State any three characteristics of electromagnetic waves.

(b) Briefly explain how and where the displacement current exists during the charging of a capacitor.

224. A double slit set-up was initially placed in a tank filled with water and the interference pattern was obtained using a laser light. When water is replaced by a transparent liquid of refractive index $n > n_{\text{water}}$, what will be the effect on the following ?

(a) Speed, frequency and wavelength of the light of laser beam.

(b) The fringe width, shape of interference fringes and shift in the position of central maximum.

225. Explain the following observations using Einstein's photoelectric equation :

(a) Photoelectric emission does not occur from a surface when the frequency of the light incident on it is less than a certain minimum value.

(b) It is the frequency, and not the intensity of the incident light which affects the maximum kinetic energy of the photoelectrons.

(c) The cut-off voltage (V_0) versus frequency (v) of the incident light curve is a straight line with a slope $\frac{h}{e}$.

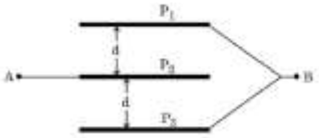
226. (a) What are majority and minority charge carriers of p-type and n-type semiconductors?

(b) Explain briefly the formation of diffusion current and drift current in a p-n junction diode.

SECTION D

Questions number 29 and 30 are Case Study-based questions. Read the following paragraphs and answer the questions that follow.

227. A parallel plate capacitor consists of two conducting plates kept generally parallel to each other at a distance. When the capacitor is charged, the charge resides on the inner surfaces of the plates and an electric field is set up between them. Thus, electrostatic energy is stored in the capacitor. The figure shows three large square metallic plates, each of side ' L ' held parallel and equidistant from each other. The space between P_1 and P_2 and P_2 and P_3 is completely filled with mica sheets of dielectric constant ' K '. The plate P_2 is connected to point A and other plates P_1 and P_3 are connected to point B . Point A is maintained at a positive potential with respect to point B and the potential difference between A and B is V.



(i) The capacitance of the system between A and B will be :

(a) $\frac{\varepsilon_0 KL^2}{d}$ (b) $\frac{\varepsilon_0 KL^2}{2d}$

(c) $\frac{2\varepsilon_0 KL^2}{d}$ (d) $\frac{2\varepsilon_0 Kd}{L^2}$

(ii) The charge on plate P_1 is:

(a) $\frac{\varepsilon_0 VKL^2}{2\,d}$ (b) $\frac{\varepsilon_0 VKL^2}{d}$

(c) $\frac{2r_0 VKL^2}{d}$ (d) $\frac{\varepsilon_0 VKL^{\overline{2}}}{4\,d}$

(iii) The electric field in the region between P_1 and P_2 is :

(a) $\frac{V}{d}$ (b) $\frac{2\,V}{d}$

(c) $\frac{V}{2\,d}$ (d) $\frac{d}{V}$

(iv) (a) The separation between the plates of same area $\left(L^2\right)$ of a parallel plate air capacitor having capacitance equal to that of this system, will be :

(a) $\frac{d}{K}$ (b) $\frac{2\,d}{K}$

(c) $\frac{d}{2\,K}$ (d) $\frac{d}{4\,K}$

OR

(b) If the source of potential difference applied between A and B is removed, and then A and B are connected by a conducting wire, the net charge on the system will be :

(a) $\frac{\varepsilon_0 VKL^2}{4\,d}$ (b) $\frac{\varepsilon_0 VKL^2}{2\,d}$

(c) $\frac{\varepsilon_0 VKL^2}{d}$ (d) Zero

228. A hydrogen atom consists of an electron revolving in a circular orbit of radius r with certain velocity v around a proton located at the nucleus of the atom. The electrostatic force of attraction between the revolving electron and the proton provides the requisite centripetal force to keep it in the orbit. According to Bohr's model, an electron can revolve only in certain stable orbits. The angular momentum of the electron in these orbits is some integral multiple of $\frac{h}{2\pi}$, where h is the Planck's constant. Further, when an electron makes a transition from one orbit of higher energy to that of lower energy, a photon is emitted having energy equal to the difference between energies of the initial and final states. Assuming the mass and charge of an electron as m and e respectively, answer the following questions.

(i) The expression for the speed of electron v in terms of radius of the orbit (r) and physical constant ($K = \frac{1}{4\pi\varepsilon_0}$) is :

(a) $\frac{Ke^2}{mr}$ (b) $\frac{Ke^2}{mr^2}$

(c) $\sqrt{\frac{Ke^2}{mr}}$ (d) $\sqrt{\frac{Ke^2}{mr^2}}$

(ii) The total energy of the atom in terms of r and physical constant K is:

(a) $\frac{Ke^2}{r}$ (b) $-\frac{Ke^2}{2r}$

(c) $\frac{Ke^2}{2r}$ (d) $\frac{3}{2}\frac{Ke^2}{r}$

(iii) A photon of wavelength 500 nm is emitted when an electron makes a transition from one state to the other state in an atom. The change in the total energy of the electron and change in its kinetic energy in eV as per Bohr's model, respectively will be :

(a) $2.48, -2.48$ (b) $-1.24, 1.24$

(c) $-2 \cdot 48, 2 \cdot 48$ (d) $1 \cdot 24, -1 \cdot 24$

(iv) (a) In Bohr's model of hydrogen atom, the frequency of revolution of electron in its n^{th} orbit is proportional to :

(a) n (b) $\frac{1}{n}$

(c) $\frac{1}{n^2}$ (d) $\frac{1}{n^3}$

OR

(b) An electron makes a transition from -3.4 eV state to the ground state in hydrogen atom. Its radius of orbit changes by : (radius of orbit of electron in ground state $= 0.53$Å)

(a) 0.53Å (b) 1.06Å

(c) 1.59Å (d) $2 \cdot 12$Å

SECTION E

229. (a) (i) Two point charges $+q$ and $-q$ are held at $(a, 0)$ and $(-a, 0)$ in $x-y$ plane. Obtain an expression for the net electric field due to the charges at a point $(0, y)$. Hence, find electric field at a far off point $(y \gg a)$.

(ii) Three point charges of $-2\mathrm{nC}, -1\mathrm{nC}$, and +5 nC are kept at the vertices A, B and C of an equilateral triangle of side 0.2 m . Find the total amount of work done in shifting the charges from A to A_1, B to B_1 and C to C_1. Here A_1, B_1 and C_1 are the midpoints of sides AB, BC and CA, respectively.

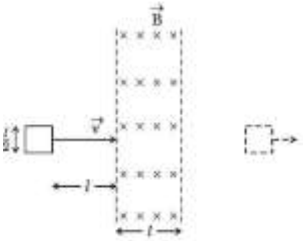
OR

(b) (i) Show that Gauss's theorem is consistent with Coulomb's law. Using it, derive an expression for the electric field due to a uniformly charged thin spherical shell of radius r at a point at a distance y from the centre of the shell such that (I) $y > r$, and (II) $y < r$.

(ii) A point charge of +2 nC is kept at the origin of a three-dimensional coordinate system. Find the type and magnitude of the charge which should be kept at $(0, 0, -6\text{ m})$ so that the potential due to the system becomes zero at $(0, 0, 2\text{ m})$.

230. (a) (i) State Lenz's law and explain how this law is a consequence of conservation of energy principle.

(ii) A square shaped loop of side $\frac{l}{2}$ is initially lying outside a region of uniform magnetic field $\vec{B}$ as shown in the figure. The loop is moved towards right with a constant velocity $\vec{v}$ till it goes out of the region of magnetic field.



(I) What will be the directions of induced current when the loop enters the field and when it leaves the field?

(II) Draw the plots showing the variation of magnetic flux ϕ linked with the loop with time t and variation of induced emf E with time t. Mark the relevant values of E, ϕ and t on the graphs.

OR

(b) (i) Differentiate between peak and rms values of alternating current. How are they related?

(ii) A current element X is connected across an ac source of emf $V = V_0 \sin 2\pi\nu t$. It is found that the voltage leads the current in phase by $\frac{\pi}{2}$ radian. If element X was replaced by element Y , the voltage lags behind the current in phase by $\frac{\pi}{2}$ radian.

(I) Identify elements X and Y by drawing phasor diagrams.

(II) Obtain the condition of resonance when both elements X and Y are connected in series to the source and obtain expression for resonant frequency. What is the impedance value in this case?

231. (a) (i) An object is placed 30 cm from a thin convex lens of focal length 10 cm . The lens forms a sharp image on a screen. If a thin concave lens is placed in contact with the convex lens, the sharp image on the screen is formed when the screen is moved by 45 cm from its initial position. Calculate the focal length of the concave lens.

(ii) Calculate the angle of minimum deviation of an equilateral prism. The refractive index of the prism is $\sqrt{3}$. Calculate the angle of incidence for this case of minimum deviation also.

OR

(b) (i) A physics teacher wants to demonstrate interference with the help of double slit experiment using a laser beam of 633 nm wavelength. Since the hall is large enough, interference pattern is formed on the wall 5.0 m from the slits. For clear and comfortable view by all the students they want the fringe width 5 mm .

(I) Find the slit separation for obtaining the desired interference pattern.

(II) How far will the first minimum be from the central maximum?

(ii) A parallel beam of light of wavelength 650 nm passes through a slit of width 0.6 mm . The diffraction pattern is obtained on a screen kept 60 cm away from the slit. Find the distance between first order minima on both sides of the central maximum.

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$\varepsilon_0 = 8.854 \times 10^{-12}$C^2 N^{-1} m^{-2}
$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^{2}C^{-2}
Mass of electron $(m_e) = 9.1 \times 10^{-31}$ kg.
Mass of neutron $= 1.675 \times 10^{-27}$ kg.
Mass of proton $= 1.673 \times 10^{-27}$ kg.
Avogadro's number $= 6.023 \times 10^{23}$ per gram mole
Boltzmann's constant $= 1.38 \times 10^{-23}$JK^{-1}

SECTION-A

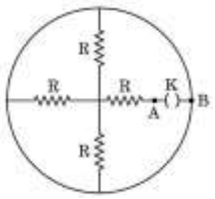
232. A metal sheet is inserted between the plates of a parallel plate capacitor of capacitance C. If the sheet partly occupies the space between the plates, the capacitance:

(a)remains C
(b)becomes greater than C
(c)becomes less than C
(d)becomes zero

233. The electric field at a point in a region is given by $\vec{E} = \alpha \frac{\vec{r}}{|\vec{r}|^3}$, where α is a constant and r is the distance of the point from the origin. The magnitude of potential of the point is:

(a)$\frac{\alpha}{r}$ (b)$\frac{\alpha r^2}{2}$
(c)$\frac{\alpha}{2r^2}$ (d)$-\frac{\alpha}{r}$

234. Four resistors, each of resistance R and a key K are connected as shown in the figure. The equivalent resistance between points A and B when key K is open, will be:



(a)4 R (b)∞
(c)$\frac{R}{4}$ (d)$\frac{4R}{3}$

235. A charged particle gains a speed of $10^6\ \text{ms}^{-1}$, when accelerated from rest through a potential difference 10 kV. It enters a region of magnetic field of 0.4 T such that $\vec{v} \perp \vec{B}$. The radius of circular path described by it is:

(a)2.5 cm (b)5 cm

(c)8 cm (d)10 cm

236. A current of $\left(\frac{10}{\pi}\right)$ A is maintained in a circular loop of radius 14 cm. The value of dipole moment associated with the loop is:

(a)0.019Am^2 (b)0.14Am^2

(c)0.196Am^2 (d)0.615Am^2

237. The magnetic flux linked with a coil changes with time t as $\phi = (8t^2 + 5t + 7)$, where t is in seconds and ϕ is in Wb. The value of emf induced in the coil at $t = 4\ s$ is:

(a)32 V (b)37 V

(c)64 V (d)69 V

238. Which of the following rays coming from the Sun plays an important role in maintaining the Earth's warmth?

(a)Infrared rays (b)γ rays

(c)UV rays (d)Visible light rays

239. The dimensions of $(\mu\varepsilon)^{-1}$, where ε is permittivity and μ is permeability of a medium, are :

(a)$[\text{M}^0\ \text{L}^1\ \text{T}^{-1}]$ (b)$[\text{M}^0\ \text{L}^2\ \text{T}^{-2}]$

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

240. Which of the following electromagnetic waves has photons of largest momentum?

(a)X-rays (b)AM radio waves

(c)Microwaves (d)TV waves

241. A compound microscope has an objective and an eyepiece of focal lengths f_o and f_e, respectively. To obtain a large magnification of a small object, the microscope should have :

(a)f_o and f_e small, and $f_e > f_o$

(b)f_o and f_e small, and $f_o > f_e$

(c)f_o and f_e large, and $f_e > f_o$

(d)f_o and f_e large, and $f_o > f_e$

242. Two coherent light waves, each having amplitude ' a ', superpose to produce an interference pattern on a screen. The intensity of light as seen on the screen varies between :

(a)0 and 2a^2 (b)0 and 4a^2

(c)a^2 and 2a^2 (d)$2a^2$ and $4a^2$

243. The kinetic energy of an alpha particle is four times the kinetic energy of a proton. The ratio $\left(\frac{\lambda_{at}}{\lambda_p}\right)$ of de Broglie wavelengths associated with them will be :

(a)$\frac{1}{16}$ (b)$\frac{1}{8}$

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

Questions number 13 to 16 are Assertion (A)and Reason (R) type questions. Two statements are given - one labelled Assertion (A)and the other labelled Reason (R). Select the correct answer from the codes (A), (B), (C)and (D)as given below.

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

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

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

(d)Both Assertion (A)and Reason (R) are false.

244. Assertion (A): The impurities in p-type Si are not pentavalent atoms.

Reason (R): The hole density in valance band in p -type semiconductor is almost equal to the acceptor density.

245. **Assertion (A):** During formation of a nucleus, the mass defect produced is the source of the binding energy of the nucleus.
Reason (R): For all nuclei, the value of binding energy per nucleon increases with mass number.
246. **Assertion (A):** The Balmer series in hydrogen atom spectrum is formed when the electron jumps from higher energy state to the ground state.
Reason (R): In Bohr's model of hydrogen atom, the electron can jump between successive orbits only.
247. **Assertion (A):** In Rutherford's alpha particle scattering experiment, the presence of only few alpha particles at angle of scattering π led him to the discovery of nucleus.
Reason (R) : The size of nucleus is approximately 10^{-5} times the size of an atom and therefore only few alpha particles are rebounded.

SECTION B

248. The threshold frequency for a given metal is 3.6×10^{14} Hz. If monochromatic radiations of frequency 6.8×10^{14} Hz are incident on this metal, find the cut-off potential for the photoelectrons.

249. (a)A point object is placed in air at a distance $R/3$ in front of a convex surface of radius of curvature R, separating air from a medium of refractive index $n(< 4)$. Find the nature and position of the image formed.

OR

(b)In Young's double slit experimental set-up, the intensity of the central maximum is I_0. Calculate the intensity at a point where the path difference between two interfering waves is $\lambda/3$.

250. A voltmeter of resistance 1000Ω can measure up to 25 V. How will you convert it so that it can read up to 250 V?

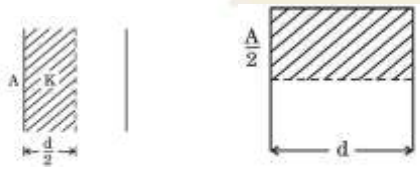
251. When a neutron collides with ${}^{235}_{92}U$, the nucleus gives ${}^{140}_{54}Xe$ and ${}^{94}_{38}Sr$ as fission products and two neutrons are ejected. Calculate the mass defect and the energy released (in MeV) in the process.
Given:
$m({}^{235}_{92}U) = 235.04393u$, $m({}^{140}_{54}Xe) = 139.92164u$
$m({}^{94}_{38}Sr) = 93.91536u$, ${}^{1}_{0}n = 1.00866u$
$1u = 931MeV/c^2$

252. The resistance of a wire at $25^\circ C$ is 10.0Ω. When heated to $125^\circ C$, its resistance becomes 10.5Ω. Find (i) the temperature coefficient of resistance of the wire, and (ii) the resistance of the wire at $425^\circ C$.

SECTION C

253. (a)Draw the energy-band diagrams for conductors, semiconductors and insulators at T = 0 K. How is an electron-hole pair formed in a semiconductor at room temperature?
(b)Carbon and silicon both, are members of IV group of periodic table and have the same lattice structure. Carbon is an insulator whereas silicon is a semiconductor. Explain.

254. A parallel plate capacitor has plate area A and plate separation d. Half of the space between the plates is filled with a material of dielectric constant K in two ways as shown in the figure.



(a) (b)

Find the values of the capacitance of the capacitors in the two cases.

255. In Young's double slit experiment, the separation between the two slits is 1.0 mm and the screen is 1.0 m away from the slits. A beam of light consisting of two wavelengths 500 nm and 600 nm is used to obtain interference fringes. Calculate :
(a)the distance between the first maxima for the two wavelengths.
(b)the least distance from the central maximum, where the bright fringes due to both the wavelengths coincide.

256. **Differentiate between half-wave and full-wave rectification. With the help of a circuit diagram, explain the working of a full-wave rectifier.**

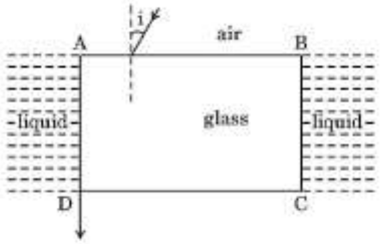
257. **An electron of mass m and charge - e is revolving anticlockwise around the nucleus of an atom.**

(a)Obtain the expression for the magnetic dipole moment (μ) of the atom.

(b)If $\vec{L}$ is the angular momentum of electron, show that

$$\vec{\mu} = -\left(\frac{e}{2m}\right)\vec{L}.$$

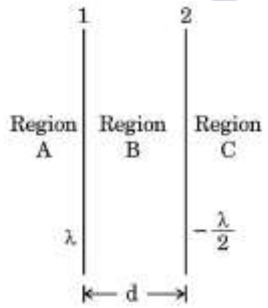
258. **A rectangular glass slab ABCD (refractive index 1.5) is surrounded by a transparent liquid (refractive index 1-25) as shown in the figure. A ray of light is incident on face AB at an angle i such that it is refracted out grazing the face AD. Find the value of angle i.**



259. **(a)Two small solid metal balls A and B of radii R and $2R$ having charge densities 2σ and 3σ respectively are kept far apart. Find the charge densities on A and B after they are connected by a conducting wire.**

OR

(b)Two infinitely long straight wires ' 1 ' and ' 2 ' are placed d distance apart, parallel to each other, as shown in the figure. They are uniformly charged having charge densities λ and $-\frac{\lambda}{2}$ respectively. Locate the position of the point from wire ' 1 ' at which the net electric field is zero and identify the region in which it lies.



SECTION D

Questions number 29 and 30 are Case Study-based questions. Read the following paragraphs and answer the questions that follow.

260. **A galvanometer is an instrument used to show the direction and strength of the current passing through it. In a galvanometer, a coil placed in a magnetic field experiences a torque and hence gets deflected when a current- passes through it. The name is derived from the surname of Italian scientist L. Galvani, who in 1791 discovered that electric current makes a dead frog's leg jerk. A spring attached with the coil provides a counter torque.**

In equilibrium, the deflecting torque is balanced by the restoring torque of the spring and we have:

$NBAI = k\phi$

where N is the total number of turns in the coil

A is the area of cross-section of each turn

B is the radial magnetic field

k is the torsional constant of the spring

ϕ is the angular deflection of the coil

As the current (I_g) which produces full scale deflection in the galvanometer is very small, the galvanometer cannot as such be used to measure current in electric circuits. A small resistance, called

shunt, of a suitable value is connected with the galvanometer to convert it into an ammeter of desired range. By using a higher resistance, a galvanometer can also be converted into a voltmeter.

(i) The value of the current sensitivity of a galvanometer is given by :

(a)$\frac{k}{NBA}$ (b)$\frac{NBA}{k}$

(c)$\frac{kBA}{N}$ (d)$\frac{kNB}{A}$

(ii) A galvanometer of resistance 6Ω shows full scale deflection for a current of $0-2$ A. The value of shunt to be used with this galvanometer to convert it into an ammeter of range $(0-5\text{ A})$ is :

(a)0.25Ω (b)0.30Ω

(c)0.50Ω (d)6.0Ω

(iii) The value of resistance of the ammeter in case (ii) will be :

(a)0.20Ω (b)0.24Ω

(c)6.0Ω (d)6.25Ω

(iv) (a)A galvanometer is converted into a voltmeter of range ($0-V$) by connecting with it, a resistance R_1. If R_1 is replaced by R_2, the range becomes ($0-2$ V). The resistance of the galvanometer is :

(a) (R_2-2R_1) (b)(R_2-R_1)

(c) (R_1+R_2) (d)(R_1-2R_2)

OR

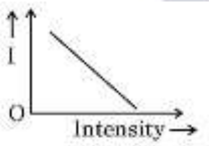
(b)A current of 5 mA flows through a galvanometer. Its coil has 100 turns, each of area of cross-section 18 cm^2 and is suspended in a magnetic field 0.20 T . The deflecting torque acting on the coil will be :

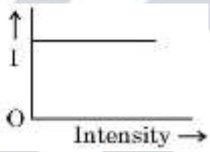
(a)3.6×10^{-3}Nm (b)1.8×10^{-4}Nm

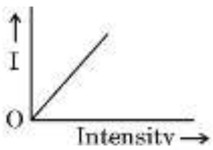
(c)2.4×10^{-3}Nm (d)1.2×10^{-4}Nm

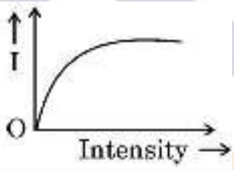
261. Einstein explained photoelectric effect on the basis of Planck's quantum theory, where light travels in the form of small bundles of energy called photons. The energy of each photon is $h\nu$, where ν is the frequency of incident light and h is Planck's constant. The number of photons in a beam of light determines the intensity of the incident light. A photon incident on a metal surface transfers its total energy $h\nu$ to a free electron in the metal. A part of this energy is used in ejecting the electron from the metal and is called its work function. The rest of the energy is carried by the ejected electron as its kinetic energy.

(i) Which of the following graphs shows the variation of photoelectric current I with the intensity of light?

(a)


(b)


(c)


(d)


(ii) When the frequency of the incident light is increased without changing its intensity, the saturation current :

(a)increases linearly

(b)decreases

(c)increases non-linearly

(d)remains the same

(iii) Which of the following graphs can be used to obtain the value of Planck's constant?

(a)Photocurrent versus Intensity of incident light

(b)Photocurrent versus Frequency of incident light

(c)Cut-off potential versus Frequency of incident light

(d)Cut-off potential versus Intensity of incident light

(iv) (a)Red light, yellow light and blue light of the same intensity are incident on a metal surface successively. K_R, K_Y and K_B represent the maximum kinetic energy of photoelectrons respectively, then :

(a)$K_R>K_Y>K_B$ (b)$K_Y>K_B>K_R$

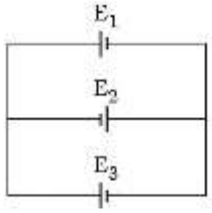
(c)$K_B>K_Y>K_R$ (d)$K_R>K_B>K_Y$

OR

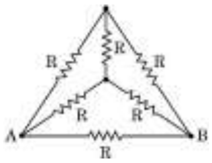
(b)Which of the following metals exhibits photoelectric effect with visible light?
(a)Caesium (b)Zinc
(c)Cadmium (d)Magnesium

SECTION E

262. (a) (i) Three batteries E_1, E_2 and E_8 of emfs and internal resistances (4 V, 2Ω), (2 V, 4Ω) and (6 V, 2Ω) respectively are connected as shown in the figure. Find the values of the currents passing through batteries E_1, E_2 and E_3.

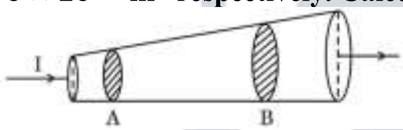


(ii) The ends of six wires, each of resistance $R(= 10\Omega)$ are joined as shown in the figure. The points A and B of the arrangement are connected in a circuit. Find the value of the effective resistance offered by it to the circuit.



OR

(b) (i) Current $I(= 1\text{ A})$ is passing through a copper rod $\left(n = 8.5 \times 10^{28}\text{ m}^{-3}\right)$ of varying cross-sections as shown in the figure. The areas of cross-section at points *A* and *B* along its length are $1.0 \times 10^{-7}\text{ m}^2$ and $2.0 \times 10^{-7}\text{ m}^2$ respectively. Calculate:



(I) the ratio of electric fields at points A and B .
(II) the drift velocity of free electrons at point B .
(ii) Two point charges $q_1(= 16\mu\text{C})$ and $q_2(= 1\mu\text{C})$ are placed at points $\vec{r}_1 = (3\text{ m})\hat{\imath}$ and $\vec{r}_2 = (4\text{ m})\hat{\jmath}$. Find the net electric field $\vec{E}$ at point $\vec{r} = (3\text{ m})\hat{\imath} + (4\text{ m})\hat{\jmath}$.

263. (a) (i) Define self-inductance of a coil. Derive the expression for the energy required to build up a current I in a coil of self-inductance *L*.
(ii) The currents passing through two inductors of self-inductances 10 mH and 20 mH increase with time at the same rate.
Draw graphs showing the variation of:
(I) the magnitude of emf induced with the rate of change of current in each inductor.
(II) the energy stored in each inductor with the current flowing through it.

OR

(b) (i) Define the term mutual inductance. Deduce the expression for the mutual inductance of two long coaxial solenoids of the same length having different radii and different number of turns.
(ii) The current through an inductor is uniformly increased from zero to 2 A in 40 s. An emf of 5 mV is induced during this period. Find the flux linked with the inductor at $t = 10$ s.

264. (a)(i) Draw a ray diagram of a reflecting telescope (Cassegrain) and explain the formation of image. State two important advantages that a reflecting telescope has over a refracting telescope.
(ii) In a refracting telescope, the focal length of the objective is 50 times the focal length of the eyepiece. When the final image is formed at infinity, the length of the tube is 102 cm. Find the focal lengths of the two lenses.

OR

(b)(i) Write any two advantages of a compound microscope over a simple microscope. Draw a ray diagram for the image formation at the near point by a compound microscope and explain it.

General Instructions :

Read the following instructions very carefully and follow them:

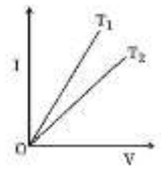
(i) This question paper contains 33 questions. All questions are compulsory.
(ii) Question paper is divided into FIVE sections - Sections A, B, C, D and. E
(iii) In Section A: Question numbers 1 to 16 are Multiple Choice (MCQ) type questions. Each question carries 1 mark.
(iv) In Section B: Question numbers 17 to 21 are Very Short Answer (VSA) type questions. Each question carries 2 marks.
(v) In Section C: Question numbers 22 to 28 are Short Answer (SA) type questions. Each question carries 3 marks.
(vi) In Section D: Question numbers 29 & 30 are Case Study-Based questions. Each question carries 4 marks.
(vii) In Section E: Question numbers 31 to 33 are Long Answer (LA) type questions. Each question carries 5 marks.
(viii) There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the Sections except Section A.
(ix) Kindly note that there is a separate question paper for Visually Impaired candidates.
(x) Use of calculators is NOT allowed.

You may use the following values of physical constants wherever necessary:

$c = 3 \times 10^8\ m/s$
$h = 6.63 \times 10^{-34} Js$
$e = 1.6 \times 10^{-19} C$
$\mu_0 = 4\pi \times 10^{-7} TmA^{-1}$
$\varepsilon_0 = 8.854 \times 10^{-12} C^2\ N^{-1}\ m^{-2}$
$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ N\ m^2 C^{-2}$
Mass of electron $(m_e) = 9.1 \times 10^{-31}$ kg.
Mass of neutron $= 1.675 \times 10^{-27}$ kg.
Mass of proton $= 1.673 \times 10^{-27}$ kg.
Avogadro's number $= 6.023 \times 10^{23}$ per gram mole
Boltzmann's constant $= 1.38 \times 10^{-23} JK^{-1}$

SECTION-A

265. The figure shows the voltage (V) versus the current (I) graphs for a wire at two temperatures T_1 and T_2. One can conclude that:

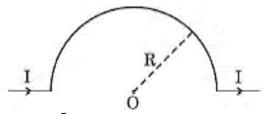


(a) $T_2 = 2\ T_1$ (b) $T_1 > T_2$
(c) $T_1 = T_2/3$ (d) $T_1 < T_2$

266. If R_s and R_p are the equivalent resistances of n resistors, each of value R, in series and parallel combinations respectively, then the value of ($R_5 - R_p$) is :

(a) $\left(\frac{n^2-1}{n^2}\right) R$ (b) $\left(\frac{n^2+1}{n^2-1}\right) R$
(c) $\left(\frac{n^2-1}{n}\right) R$ (d) $\frac{(n^2+1)R}{n^2}$

267. The value of magnetic field at point O in the given figure is :



(a)$\frac{\mu_0 I}{2\pi R}$ (b)$\frac{\mu_0 I}{\pi R}$

(c)$\frac{\mu_0 I}{4R}$ (d)$\frac{\mu_0 I}{R}$

268. A piece of a diamagnetic material, free to move when placed in a uniform magnetic field:

(a)moves along the field

(b)moves opposite to the field

(c)moves perpendicular to the field

(d)does not move at all

269. A galvanometer can be converted into an ammeter of desired range by connecting a:

(a)small resistance in series

(b)large resistance in series

(c)small resistance in parallel

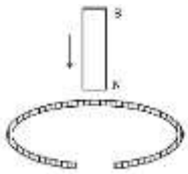
(d)large resistance in parallel

270. A proton and an α-particle enter with the same velocity $\vec{v}$ in a uniform magnetic field $\vec{B}$ such that $\vec{v} \perp \vec{B}$. The ratio of the radii of their paths is:

(a)2 (b)$\frac{1}{2}$

(c)$\frac{1}{4}$ (d)4

271. A vertically held bar magnet is dropped along the axis of a copper ring having a cut as shown in the diagram. The acceleration of the falling magnet is:



(a)zero (b)less than g

(c)g (d)greater than g

272. An ac source is connected to a resistor and an inductor in series. The voltage across the resistor and inductor are 8 V and 6 V respectively. The voltage of the source is:

(a)10 V (b)12 V

(c)14 V (d)16 V

273. Two coherent waves, each of intensity I_0, produce interference pattern on a screen. The average intensity of light on the screen is:

(a)zero (b)I_0

(c)$2I_0$ (d)$4I_0$

274. The work function of a material is 2.21 eV. Which of the following cannot produce photoelectrons from it?

(a)Red light (b)Blue light

(c)Violet light (d)Green light

275. The momentum (in kgm/s) of a photon of frequency 6.0×10^{14} Hz is :

(a)6.63×10^{-25} (b)1.326×10^{-27}

(c)2.652×10^{-26} (d)3.978×10^{-24}

276. Inside a nucleus, the nuclear forces between proton and proton, proton and neutron, neutron and neutron are F_{pp}, F_{pn} and F_{nn} respectively. Then :

(a)$F_{pp} > F_{pn} > F_{nn}$ (b)$F_{pn} > F_{nn} > F_{pp}$

(c)$F_{nn} > F_{pp} > F_{pn}$ (d)$F_{pp} = F_{pn} = F_{nn}$

Questions number 13 to 16 are Assertion (A)and Reason (R) type questions. Two statements are given - one labelled Assertion (A)and the other labelled Reason (R). Select the correct answer from the codes (A), (B), (c)and (d)as given below.

(a)Both Assertion (A)and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).
(b)Both Assertion (a)and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).
(c)Assertion (A)is true, but Reason (R) is false.
(d)Both Assertion (A)and Reason (R) are false.

277. Assertion (A): In a reflecting telescope, the image does not have chromatic aberration.
Reason (R): Chromatic aberration occurs only due to refraction of light through an optical medium.

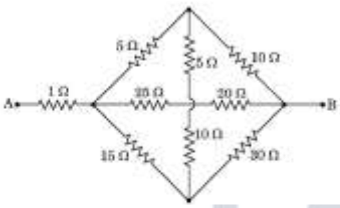
278. Assertion (A): A hole is an apparent free particle with effective positive electronic charge.
Reason (R): A hole is not necessarily a vacancy left behind by an electron in the valence band.

279. Assertion (A): X-rays are produced when slow moving electrons are stopped by a metal target of high atomic number.
Reason (R): X-rays consist of low-energy photons.

280. Assertion (A): The binding energy per nucleon is practically constant for mass number in the range ($30 < A < 170$).
Reason (R): Nuclear forces between the nucleons for mass numbers in the range ($30 < A < 170$) are not short-range.

SECTION B

281. Find the equivalent resistance between points A and B for the network shown in the figure.



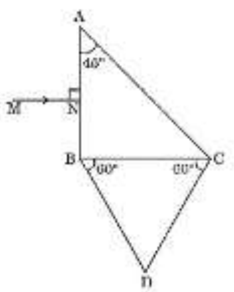
282. (a)Find the intensity at a point on the screen in Young's double slit experiment, at which the interfering waves of intensity I_0 each, have a path difference of (i) $\frac{\lambda}{3}$, and (ii) $\frac{\lambda}{2}$.

OR

(b)A point source of light in air is kept at a distance of 12 cm in front of a convex spherical surface of glass of refractive index 1.5 and radius of curvature 30 cm . Find the nature and position of the image formed.

283. A laser beam of frequency 3.0×10^{14} Hz produces average power of 9 mW . Find (i) the energy of photon of the beam, and (ii) the number of photons emitted per second on an average by the source.

284. A right angled isosceles glass prism ABC is kept in contact with an equilateral triangular prism DBC as shown in the figure. Both prisms are made of the same glass of Trace the path of the ray MN incident normally on face AB as it passes through the combination.

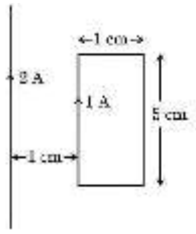


285. In an n-type semiconductor electron-hole combination is a continuous process at room temperature. Yet the electron concentration is always greater than the hole concentration in it. Explain.

SECTION C

286. What is the difference between 'emf' and 'terminal voltage' of a cell?
Two cells of emfs E_1 and E_2 and internal resistances r_1 and r_2 are connected in parallel. Derive an expression for the emf and internal resistance of the equivalent cell.

287. A rectangular loop carries a current of 1 A. A straight long wire carrying 2 A current is kept near the loop in the same plane as shown in the figure.



Find:
(i) the torque acting on the loop, and
(ii) the magnitude and direction of the net force on the loop.

288. (a) State Lenz's law. A rod MN of length L is rotated about an axis passing through its end M perpendicular to its length, with a constant angular velocity ω in a uniform magnetic field $\vec{B}$ parallel to the axis. Obtain an expression for emf induced between its ends.

OR

(b) Define 'self-inductance' of a coil. Derive an expression for self-inductance of a long solenoid of cross-sectional area A and length l, having n turns per unit length.

289. Name the electromagnetic wave used (i) in radar, (ii) in eye surgery and (iii) as diagnostic tool in medicine. Write their wavelength range also.

290. Draw a ray diagram showing the image formation when a concave mirror produces a real, inverted and magnified image of an object and hence obtain the mirror formula.

291. How is the necessary force provided to an electron to keep it moving in a circular orbit according to Bohr model of hydrogen atom ? Derive an expression for the total energy of an electron moving in an orbit of radius r in hydrogen atom. Give the significance of negative sign in this expression.

292. (a)Consider the so-called 'D-T reaction' (Deuterium-Tritium reaction). In a thermonuclear fusion reactor, the following nuclear reaction occurs:

$^{2}_{1}H + ^{3}_{1}H \longrightarrow ^{4}_{2}He + ^{1}_{0}n + Q$

Find the amount of energy released in the reaction.
Given:
$m(^{2}_{1}H) = 2 \cdot 014102u$
$m(^{3}_{1}H) = 3 \cdot 016049u$
$m(^{4}_{2}He) = 4 \cdot 002603u$
$m(^{1}_{0}n) = 1 \cdot 008665u$
$1u = 931 MeV/c^2$

(b)Show that the nuclear density is independent of mass number.

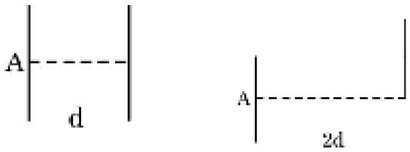
SECTION D

Questions number 29 and 30 are case study-based questions. Read the following paragraphs and answer the questions that follow.

293. A capacitor is a system of two conductors separated by an insulator. In practice, the two conductors have charges Q and -Q with potential difference $V = V_1 - V_2$ between them. The ratio $\frac{Q}{V}$ is a constant, denoted by C and is called the capacitance of the capacitor. It is independent of Q or V. It depends only on the geometrical configuration (shape, size, separation) of the two conductors and the medium separating the conductors. When a parallel plate capacitor is charged, the electric field E_0 is localised between the plates and is uniform throughout. When a slab of a dielectric is inserted between the charged plates (charge density σ), the dielectric is polarised by the field. Consequently opposite charges appear on the faces of the slab, near the plates, with surface charge density of magnitude σ_p. For a linear dielectric σ_p is proportional to E_0. Introduction of a dielectric changes the electric field, and hence, the capacitance of a capacitor, and hence, the energy stored in the capacitor.

Like resistors, capacitors can also be arranged in series or in parallel or in a combination of series and parallel.

(i) Consider a capacitor of capacitance C , with plate area A and plate separation d, filled with air [Fig. (a)]. The distance between the plates is increased to 2d and one of the plates is shifted as shown in Fig. (b). The capacitance of the new system now is:



(a) (b)

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

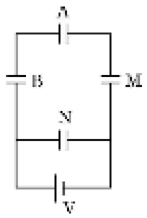
(ii) A slab (area A and thickness d_1) of a linear dielectric of dielectric constant K is inserted between charged plates (charge density σ) of a parallel plate capacitor [plate area A and plate separation $d(> d_1)$] and opposite charges with charge density of magnitude σ_p appear on the faces of the slab. The dielectric constant K is given by :

(a)$\frac{\sigma+\sigma_p}{\sigma}$ (b)$\frac{\sigma}{\sigma-\sigma_p}$
(c)$\frac{\sigma+\sigma_p}{\sigma_p}$ (d)$\frac{\sigma}{\sigma_p}$

(iii) An electric field E is established between the plates of an air filled parallel plate capacitor, with charges Q and $-Q$. V is the volume of the space enclosed between the plates. The energy stored in the capacitor is :

(a)$\frac{1}{2}\varepsilon_0 E^2$ (b)$\varepsilon_0 Q^2 E$
(c)$\frac{1}{2}\varepsilon_0 E^2\ V$ (d)$\varepsilon_0 EQV$

(iv) (a)Three capacitors A, B and M, each of capacitance C are connected to a capacitor N of capacitance 2 C and a battery as shown in the figure. If the charges on A and N are Q and Q' respectively, then $\frac{Q'}{Q}$ is:



(a)$\frac{1}{6}$ (b)$\frac{1}{3}$
(c)3 (d)6

OR

(b)A slab (area A and thickness $\frac{d}{2}$) of dielectric constant K is inserted in a parallel plate capacitor of plate area A and plate separation d. If C and C_0 are the capacitances of the capacitors with and without the dielectric, then $\frac{C}{C_0}$ is :

(a)$\frac{K+1}{2K}$ (b)$\frac{2K}{K+1}$
(c)$\frac{K}{K-1}$ (d)$\frac{K-1}{K}$

294. Extrinsic semiconductors are made by doping pure or intrinsic semiconductors with suitable impurity. There are two type of dopants used in doping, Si or Ge, and using them p-type and n-type semiconductors can be obtained. A p-n junction is the basic building block of many semiconductor devices. Two important processes occur during the formation of a p-n junction : diffusion and drift. When such a junction is formed, a 'depletion layer' is created consisting of immobile ion-cores. This is responsible for a junction potential barrier. The width of a depletion layer and the height of potential barrier changes when a junction is forward-biased or reverse-biased. A semiconductor diode is basically a p-n junction with metallic contacts provided at the ends for application of an external voltage. Using diodes, alternating voltages can be rectified.

(i) Which of the following is a donor impurity atom for Ge ?

(a)Boron (b)Antimony

(c)Aluminium (d)Indium

(ii) When a pentavalent atom occupies the position of an atom in the crystal lattice of Si , four of its electrons form covalent bonds with four silicon neighbours, while the fifth remains bound to the parent atom. The energy required to set this electron free is about:

(a)0.5 Ev (b)0.1 eV

(c)0.05 eV (d)0.01 eV

(iii) During formation of a p-n junction :

(a)a layer of negative charge on n-side and a layer of positive charge on p-side appear.
(b)a layer of positive charge on n-side and a layer of negative charge on p-side appear.
(c)the electrons on p -side of the junction move to n -side initially.
(d)initially diffusion current is small and drift current is large.

(iv) (a)In reverse-biased p − n junction :

(a)the drift current is of the order of few mA .
(b)the applied voltage mostly drops across the depletion region.
(c)the depletion region width decreases.
(d)the current increases with increase in applied voltage.

OR

(b)The output frequency of a full-wave rectifier with 50 Hz as input frequency is :

(a)25 Hz (b)50 Hz
(c)100 Hz (d)200 Hz

SECTION E

295. **(a) (i) Write the principle of working of an ac generator. Draw its labelled diagram and explain its working.**

(ii) A resistor of 400Ω, an inductor of $\left(\frac{5}{\pi}\right)$ H and a capacitor of $\left(\frac{50}{\pi}\right)$ μF are joined in series across an ac source $v = 140\sin(100\pi)tV$. Find the rms voltages across these three circuit elements. The algebraic sum of these voltages is more than the rms voltage of source. Explain.

OR

(b) (i) Write the principle of working of a transformer. With the help of a labelled diagram, explain the working of a step-up transformer.

(ii) An ideal transformer is designed to convert 50 V into 250 V. It draws 200 W power from an ac source whose instantaneous voltage is given by $v_i = 20\sin(100\pi)tV$.

Find :

(I) rms value of input current.

(II) expression for instantaneous output voltage.

(III) expression for instantaneous output current.

296. **(a) (i) Draw a ray diagram to show the image formation by a compound microscope. Obtain the expression for the total magnification of the microscope when the final image is formed at infinity.**

(ii) In a compound microscope, an object is placed at a distance of 1.5 cm from the objective of focal length 1.25 cm. The eyepiece has a focal length of 5 cm. The final image is formed at infinity. Calculate the distance between the objective and the eyepiece.

OR

(b) (i) Using Huygens' principle, explain the refraction of a plane wavefront, propagating in air, at a plane interface between air and glass. Hence verify Snell's law.

(ii) Use mirror formula to deduce that a convex mirror always produces a virtual image of an object kept in front of it.

297. **(a) (i) The electric field in a region is given by $\vec{E} = 40x\hat{i}N/C$. Find the amount of work done in taking a unit positive charge from a point ($0, 3$ m) to the point (5 m, 0).**

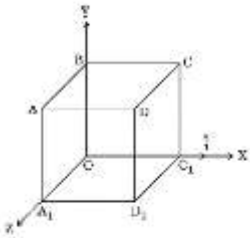
(ii) A charge Q is distributed over two concentric hollow spheres of radii r and $R(> r)$ such that their surface charge densities are equal. Find :

(I) the electric field, and

(II) the potential
at their common centre.

OR

(b) (i) Obtain an expression for the electric field $\vec{E}$ due to a dipole of dipole moment $\vec{p}$ at a point on its equatorial plane and specify its direction. Hence, find the value of electric field:
(I) at the centre of the dipole ($r = 0$), and
(II) at a point $r \gg a$,
where 2 a is the length of the dipole.
(ii) An electric field $\vec{E} = (10x + 5)\hat{i} N/C$ exists in a region in which a cube of side L is kept as shown in the figure. Here x and L are in metres. Calculate the net flux through the cube.



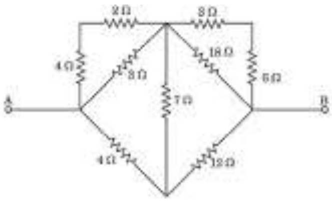
General Instructions :

Read the following instructions very carefully and follow them :
(i) This question paper contains 33 questions. All questions are compulsory.
(ii) Question paper is divided into FIVE sections - Sections A, B, C, D and E.
(iii) In Section A : Question numbers 1 to 16 are Multiple Choice (MCQ) type questions. Each question carries 1 mark.
(iv) In Section B: Question numbers 17 to 21 are Very Short Answer (VSA) type questions. Each question carries 2 marks.
(v) In Section C: Question numbers 22 to 28 are Short Answer (SA) type questions. Each question carries 3 marks.
(vi) In Section D: Question numbers 29 & 30 are Case Study-Based questions. Each question carries 4 marks.
(vii) In Section E: Question numbers 31 to 33 are Long Answer (LA) type questions. Each question carries 5 marks.
(viii) There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the Sections except Section A.
(ix) Kindly note that there is a separate question paper for Visually Impaired candidates.
(x) Use of calculators is NOT allowed.
You may use the following values of physical constants wherever necessary:
$c = 3 \times 10^8$ m/s
$h = 6.63 \times 10^{-34}$Js
$e = 1.6 \times 10^{-19}$C
$\mu_0 = 4\pi \times 10^{-7}$TmA^{-1}
$\varepsilon_0 = 8.854 \times 10^{-12} C^2 N^{-1} m^{-2}$
$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 N m^2 C^{-2}$
Mass of electron $(m_e) = 9.1 \times 10^{-31}$ kg.
Mass of neutron $= 1.675 \times 10^{-27}$ kg.
Mass of proton $= 1.673 \times 10^{-27}$ kg.
Avogadro's number $= 6.023 \times 10^{23}$ per gram mole
Boltzmann's constant $= 1.38 \times 10^{-23}$JK^{-1}

SECTION – A

298. **Two horizontal plates, separated by 1 cm , are arranged one above the other. A particle of mass 5 mg and charge 2 nC is released in air between the plates. The potential difference that should be applied to the plates so that the particle remains suspended between them, is:**
(a)250 V (b)200 V
(c)100 V (d)50 V

299. The effective resistance between points A and B in the given circuit is :



(a) 6Ω (b) $\frac{8}{3}\Omega$

(c) $\frac{16}{3}\Omega$ (d) 2Ω

300. A rectangular coil of area A is kept in a uniform magnetic field $\vec{B}$ such that the plane of the coil makes an angle α with $\vec{B}$. The magnetic flux linked with the coil is:

(a) $BA\sin\alpha$ (b) $BA\cos\alpha$

(c) BA (d) zero

301. An alternating current is given by $I = I_0\cos(100\pi)t$. The least time the current takes to decrease from its maximum value to zero will be :

(a) $\left(\frac{1}{200}\right)$ s (b) $\left(\frac{1}{150}\right)$ s

(c) $\left(\frac{1}{100}\right)$ s (d) $\left(\frac{1}{50}\right)$ s

302. A capacitor and an inductor are connected in series across an ac source of voltage of variable frequency. The frequency is increased continuously. The nature of the circuit before and after the resonance will be:

(a) inductive only

(b) capacitive only

(c) capacitive and inductive respectively

(d) inductive and capacitive respectively

303. A metal rod of length 50 cm is held vertically and moved with a velocity of 10 m/s towards east. The horizontal component of the Earth's magnetic field at the place is 0.4 G. The emf induced across the ends of the rod is:

(a) 0.1 mV (b) 0.2 mV

(c) 0.8 mV (d) 1.6 mV

304. The dimensions of 'self-inductance' are :

(a) $[MLT^{-2}A^{-2}]$ (b) $[ML^2T^{-1}A^{-1}]$

(c) $[ML^{-1}T^{-2}A^{-2}]$ (d) $[ML^2T^{-2}A^{-2}]$

305. The frequency of a photon of energy 1.326 eV is :

(a) 1.18×10^{14} Hz (b) 3.20×10^{14} Hz

(c) 4.20×10^{15} Hz (d) 4.80×10^{15} Hz

306. Germanium crystal is doped at room temperature with a minute quantity of boron. The charge carriers in the doped semiconductors will be:

(a) electrons only

(b) holes only

(c) holes and few electrons

(d) electrons and few holes

307. Out of the four options given, in which transition will the emitted photon have the maximum wavelength ?

(a) $n = 4$ to $n = 3$ (b) $n = 3$ to $n = 2$

(c) $n = 2$ to $n = 1$ (d) $n = 3$ to $n = 1$

308. A p-n junction diode is forward biased. As a result,

(a) both the potential barrier height and the width of depletion layer decrease.

(b) both the potential barrier height and the width of depletion layer increase.

(c)the potential barrier height decreases and the width of depletion layer increases.
(d)the potential barrier height increases and the width of depletion layer decreases.

309. Isotones are the nuclides having:
(a)same mass numbers
(b)same atomic numbers
(c)same neutron number, but different atomic number
(d)different neutron number, and different mass number

Questions number 13 to 16 are Assertion (A)and Reason (R) type questions. Two statements are given - one labelled Assertion (A)and the other labelled Reason (R). Select the correct answer from the codes (A), (B), (c)and (D)as given below.
(a)Both Assertion (A)and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).
(b)Both Assertion (A)and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).
(c)Assertion (A)is true, but Reason (R) is false.
(d)Both Assertion (A)and Reason (R) are false.

310. Assertion (A): A charged particle is moving with velocity v in x − y plane, making an angle $\theta\left(0<\theta<\frac{\pi}{2}\right)$ with x-axis. If a uniform magnetic field $\vec{\mathrm{B}}$ is applied in the region, along y-axis, the particle will move in a helical path with its axis parallel to x -axis.
Reason (R) : The direction of the magnetic force acting on a charged particle moving in a magnetic field is along the velocity of the particle.

311. Assertion (A): A ray of light is incident normally on the face of a prism. The emergent ray will graze along the opposite face of the prism when the critical angle at glass-air interface is equal to the angle of the prism.
Reason (R): The refractive index of a prism depends on angle of the prism.

312. Assertion (A): EM waves do not require a medium for their propagation.
Reason (R): EM waves are transverse waves.

313. Assertion (A): The minimum negative potential applied to the anode in a photoelectric experiment at which photoelectric current becomes zero, is called cut-off voltage.
Reason (R): The threshold frequency for a metal is the minimum frequency of incident radiation below which emission of photoelectrons does not take place.

SECTION B

314. A cell of emf E and internal resistance r is connected across a resistor of variable resistance R. Show graphically the variation of
(a)the terminal voltage across the cell,
(b)the current supplied by the cell,
with R as it is increased from 0 to the maximum value.

315. (a)Using the mirror equation and the formula of magnification, deduce that "the virtual image produced by a convex mirror is always diminished in size and is located between the pole and the focus."

OR

(b)A convex lens of focal length 10 cm, a concave lens of focal length 15 cm and a third lens of unknown focal length are placed coaxially in contact. If the focal length of the combination is +12 cm, find the nature and focal length of the third lens, if all lenses are thin. Will the answer change if the lenses were thick?

316. Write two differences in the patterns of double-slit interference experiment and single-slit diffraction experiment. Light waves from two pinholes illuminated by two sodium lamps do not produce interference patterns. Explain why.

317. Draw energy band diagrams of n-type and p-type semiconductors at temperature T > 0 K. Show the donor/acceptor energy levels with the order of difference of their energies from the bands.

318. Briefly explain how energy is produced in stars, giving two examples of the nuclear reactions involved.

SECTION C

319. Three cells A, B and C of emfs 2 V, 3 V and 5 V respectively are connected in parallel to each other. Their internal resistances are 5Ω, 5Ω and 1Ω respectively. Calculate the currents flowing through the cells A, B and C.

320. (a)(i) Write Biot-Savart's law in vector form.

(ii) Two identical circular coils A and B, each of radius R, carrying currents I and $\sqrt{3}I$ respectively, are placed concentrically in XY and YZ planes respectively. Find the magnitude and direction of the net magnetic field at their common centre.

OR

(b)(i) A rectangular loop of sides l and b carries a current I clockwise. Write the magnetic moment $\vec{m}$ of the loop and show its direction in a diagram.

(ii) The loop is placed in a uniform magnetic field $\vec{B}$ and is free to rotate about an axis which is perpendicular to $\vec{B}$. Prove that the loop experiences no net force, but a torque $\vec{\tau} = \vec{m} \times \vec{B}$.

321. (a)State Faraday's law of electromagnetic induction and explain the role of negative sign in its expression.

(b)Explain, with an example, that Lenz's law is consistent with the law of conservation of energy.

322. (a)Differentiate between 'conduction current' and 'displacement current', giving one similarity and one dissimilarity between them.

(b)Explain the existence of electromagnetic waves in free space, using the concept of displacement current.

323. (a)Define 'work function' of a metal. How can its value be determined from a graph between stopping potential and frequency of the incident radiation?

(b)The work function of a metal is 2.4 eV. A stopping potential of 0.6 V is required to reduce the photocurrent to zero, in a photoelectric experiment. Calculate the wavelength of light used.

324. Write the mathematical forms of three postulates of Bohr's theory of the hydrogen atom. Using them prove that, for an electron revolving in the n^{th} orbit,

(a)the radius of the orbit is proportional to n^2, and

(b)the total energy of the atom is proportional to $\left(\frac{1}{n^2}\right)$.

325. Explain the process of formation of 'depletion layer' and 'potential barrier' in a p-n junction region of a diode, with the help of a suitable diagram. Which feature of junction diode makes it suitable for its use as a rectifier?

SECTION D

Questions number 29 and 30 are case study-based questions. Read the following paragraphs and answer the questions that follow.

326. In a metallic conductor, an electron, moving due to thermal motion, suffers collisions with the heavy fixed ions but after collision, it will emerge out with the same speed but in random directions. If we consider all the electrons, their average velocity will be zero. When an electric field is applied, electrons move with an average velocity, known as drift velocity (v_d). The average time between successive collisions is known as relaxation time (τ). The magnitude of drift velocity per unit electric field is called mobility (μ).

An expression for current through the conductor can be obtained in terms of drift velocity, number of electrons per unit volume (n), electronic charge (-e), and the cross-sectional area (a)of the conductor. This expression leads to an expression between current density ($\hat{j}$) and the electric field ($\vec{E}$). Hence, an expression for resistivity (ρ) of a metal is obtained. This expression helps us to understand increase in resistivity of a metal with increase in its temperature, in terms of change in the relaxation time (τ) and change in the number density of electrons (n).

(i) Consider two cylindrical conductors A and B, made of the same metal connected in series to a battery. The length and the radius of B are twice that of A. If μ_A and μ_B are the mobility of electrons in A and B respectively, then $\frac{\mu_A}{\mu_B}$ is :

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

(ii) A wire of length 0.5 m and cross-sectional area $1.0 \times 10^{-7}\ m^2$ is connected to a battery of 2 V that maintains a current of 1.5 A in it. The conductivity of the material of the wire (in $\Omega^{-1}\ m^{-1}$) is :
(a) 2.5×10^4 (b) 3.0×10^5
(c) 3.75×10^6 (d) 5.0×10^7

(iii) The temperature coefficient of resistance of nichrome is $1.70 \times 10^{-4}\ {}^{\circ}C^{-1}$. In order to increase resistance of a nichrome wire by 8.5%, the temperature of the wire should be increased by :
(a) $250^{\circ}C$ (b) $500^{\circ}C$
(c) $850^{\circ}C$ (d) $1000^{\circ}C$

(iv) (a)Consider the contribution of the following two factors I and II in resistivity of a metal:
I. Relaxation time of electrons
II. Number of electrons per unit volume
The resistivity of a metal increases with increase in its temperature because :
(a)I decreases and II increases.
(b)I increases and II is almost constant.
(c)Both I and II increase.
(d)I decreases and II is almost constant.

OR

(b)A steady current flows in a copper wire of non-uniform cross-section. Consider the following three physical quantities:
I. Electric field
II. Current density
III. Drift speed
Then at the different points along the wire:
(a)II and III change, but I is constant.
(b)I and II change, but III is constant.
(c)I and III change, but II is constant.
(d)All I, II and III change.

327. **When light travels from an optically denser medium to an optically rarer medium, at the interface it is partly reflected back into the same medium and partly refracted to the second medium. The angle of incidence corresponding to an angle of refraction 90° is called the critical angle (i_c) for the given pair of media. This angle is related to the refractive index of medium 1 with respect to medium 2.**
Refraction of light through a prism involves refraction at two plane interfaces. A relation for the refractive index of the material of the prism can be obtained in terms of the refracting angle of the prism and the angle of minimum deviation. For a thin prism, this relation reduces to a simple equation.
Laws of refraction are also valid for refraction of light at a spherical interface. When an object is placed in front of a spherical surface separating two media, its image is formed. A relation between object and image distance, in terms of refractive indices of two media and the radius of curvature of the spherical surface can be obtained. Using this relation for two surfaces of a lens, 'lens maker formula' is obtained.

(i) A small bulb is placed at the bottom of a tank containing a transparent liquid (refractive index n) to a depth H. The radius of the circular area of the surface of liquid, through which light from the bulb can emerge out, is R. Then $\left(\frac{R}{H}\right)$ is :
(a) $\frac{1}{\sqrt{n^2-1}}$ (b) $\sqrt{n^2-1}$
(c) $\frac{1}{\sqrt{n^2+1}}$ (d) $\sqrt{n^2+1}$

(ii) (a)A parallel beam of light is incident on a face of a prism with refracting angle 60°. The angle of minimum deviation is found to be 30°. The refractive index of the material of the prism is close to :
(a)1.3 (b)1.4
(c)1.5 (d)1.6

OR

(b)The angle of minimum deviation for a ray of light incident on a thin prism, made of crown glass ($n = 1.52$) is D_m. If the prism was made of dense flint glass ($n = 1.62$) instead of crown glass, the angle of minimum deviation will :
(a)decrease by 4% (b)increase by 4%
(c)decrease by 19% (d)increase by 19%

(iii) An object is placed in front of a convex spherical glass surface ($n = 1.5$ and radius of curvature R) at a distance of $4R$ from it. As the object is moved slowly close to the surface, the image formed is :
(a)always real
(b)always virtual
(c)first real and then virtual
(d)first virtual and then real

(iv) A double-convex lens, made of glass of refractive index 1.5 , has focal length 10 cm . The radius of curvature of its each face, is :
(a)10 cm (b)15 cm
(c)20 cm (d)40 cm

SECTION E

328. (a)(i) A parallel plate capacitor with plate area A and plate separation d has a capacitance C_0. A slab of dielectric constant K having area A and thickness $\left(\frac{d}{4}\right)$ is inserted in the capacitor, parallel to the plates. Find the new value of its capacitance.

(ii) You are provided with a large number of 1μ F identical capacitors and a power supply of 1200 V. The dielectric medium used in each capacitor can withstand up to 200 V only. Find the minimum number of capacitors and their arrangement, required to build a capacitor system of equivalent capacitance of 2μ F for use with this supply.

OR

(b)(i) An electric dipole of dipole moment p consists of point charges q and -q , separated by 2 a . Derive an expression for electric potential in terms of its dipole moment at a point at a distance x (>> a) from its centre and lying (I) along its axis, and (II) along its bisector line.

(ii) An electric dipole of dipole moment $\vec{p} = (0.8\hat{\imath} + 0.6\hat{\jmath})10^{-29}$ Cm is placed in an electric field $\vec{E} = 1.0 \times 10^7 \hat{k} \frac{V}{m}$. Calculate the magnitude of the torque acting on it and the angle it makes with the x -axis, at this instant.

329. (a)(i) With the help of a labelled diagram, explain the principle of working of a moving coil galvanometer. Write the purpose of using (i) radial magnetic field, and (ii) soft iron core, in it.

(ii) Define current sensitivity of a galvanometer. "Increasing the current sensitivity may not necessarily increase the voltage sensitivity." Give reason.

OR

(b)(i) (I) Write Ampere's circuital law in mathematical form and explain the terms used.
(II) As the current carrying solenoid is made longer, the magnetic field produced outside it approaches zero. Why?
(III) A flexible loop of irregular shape carrying current when located in an external magnetic field, changes to a circular shape. Give reason.

(ii) A galvanometer of resistance G is converted into a voltmeter to measure up to V volts, by connecting a resistance R_1 in series with the coil. If R_1 is replaced by R_2, then it can only measure up to $\frac{V}{2}$ volt. Find the value of the resistance R_3 (in terms of R_1 and R_2) needed to convert it into a voltmeter that can read up to 2 V.

330. (a)(i) Explain with the help of a labelled ray diagram the formation of final image by an astronomical telescope at infinity. Write the expression for its magnifying power.

(ii) The total magnification produced by a compound microscope is 20. The magnification produced by the eyepiece is 5. When the microscope is focussed on a certain object, the distance between the objective and eyepiece is observed to be 14 cm. Calculate the focal lengths of the objective and the eyepiece. (Given that the least distance of distinct vision = 25 cm)

OR

(b)(i) Two coherent light waves, each of intensity I_0 superpose each other and produce interference pattern on a screen. Obtain the expression for the resultant intensity at a point where the phase difference between the waves is ϕ. Write its maximum and minimum possible values.

(ii) In a single slit diffraction experiment, the aperture of the slit is 3 mm and the separation between the slit and the screen is 1.5 m. A monochromatic light of wavelength 600 nm is normally incident on the slit.

Calculate the distance of (I) first order minimum, and (II) second order maximum, from the centre of the screen.

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$\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 N^{-1} m^{-2}
$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^{2}C^{-2}
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Mass of neutron $= 1.675 \times 10^{-27}$ kg
Mass of proton $= 1.673 \times 10^{-27}$ kg
Avogadro's number $= 6.023 \times 10^{28}$ per gram mole
Boltzmann constant $= 1.38 \times 10^{-28}$ JK^{-1}

SECTION –A

331. A charge of -1μC on a body represents

(a)loss of 6.25×10^{12} electrons by the body.
(b)gain of 6.25×10^{12} electrons by the body.
(c)gain of 1.6×10^{13} electrons by the body.
(d)loss of 1.6×10^{13} electrons by the body.

332. The resistance of a wire at 20°C is 50Ω. When it is heated to 120°C, the resistance becomes 51Ω. The temperature coefficient of resistance of the material of the wire is

(a)2×10^{-4} °C^{-1} (b)1×10^{-4} °C^{-1}
(c)5×10^{-1} °C^{-1} (d)1×10^{-3} °C^{-1}

333. A particle of mass m and charge q moving with a velocity $\vec{V}$ at right angle to a magnetic field $\vec{B}$, experiences a force $\vec{F}$. Another particle of mass 2 m and charge 2 q enters the same field $\vec{B}$ with a velocity $\frac{\vec{V}}{2}$, in the same direction. This particle will experience a force

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

334. A 5.0 cm long wire carrying 1.0 A current is kept in a region in which a uniform magnetic field of 0.3 T is applied perpendicular to the length of the wire. The magnitude of the force acting on the wire is -

(a)zero (b)0.45 N
(c)0.03 N (d)0.015 N

335. A step up transformer -

(a)decreases the current to transmit power over short distances with minimum loss.
(b)increases the current to transmit power over short distances with minimum loss.

(c)increases the voltage to transmit power over short distances with minimum loss.
(d)increases the voltage to transmit power over long distances with minimum loss.

336. The magnetic flux through a loop changes from 3.6 Wb to 1.6 Wb in 0.4 s . The magnitude of the induced emf in the loop is -

(a)5 V (b)2.5 V
(c)1.5 V (d)0.5 V

337. The electromagnetic radiation used to kill germs in water purifiers is

(a)Ultraviolet rays (b)Infrared waves
(c)Visible rays (d)γ-rays

338. Two thin lenses of focal lengths +40 cm and -20 cm and placed coaxially in contact. An object is placed at infinity, in front of the combination. The image formed by the combination will lie-

(a)at a distance of 60 cm , in front of the combination.
(b)at a distance of 40 cm , in front of the combination.
(c)at a distance of 20 cm , behind the combination.
(d)at infinity

339. The de-Broglie wavelengths associated with an electron (mass m_e) and a proton (mass m_p) moving with the same velocity are λ_e and λ_p respectively. The value of (λ_e/λ_p) is -

(a) $\sqrt{\frac{m_p}{m_e}}$ (b)$\frac{m_p}{m_e}$

(c)$\frac{m_e}{m_p}$ (d) $\sqrt{\frac{m_e}{m_p}}$

340. Which one out of the following transitions of an electron in Bohr's model of hydrogen atom will emit a photon with the greatest frequency?

(a)n = 3 to n = 1 (b)n = 3 to n = 2
(c)n = 4 to n = 3 (d)n = 4 to n = 2

341. The general purpose diode is normally used in -

(a)beyond cut-in voltage region
(b)before cut-in voltage region.
(c)beyond the reverse saturation current region.
(d)before the reverse saturation current region.

342. Which of the following impurity atoms when doped in silicon, would produce a p-type semiconductor?

(a)Phosphorus (b)Arsenic
(c)Antimony (d)Boron

For question numbers 13 to 16, two statements are given - one labelled as Assertion (A)and the other labelled as Reason (R). Select the correct answer to these questions from the codes (A), (B), (c)and (d)as given below :

(a)If both Assertion (A)and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(b)If both Assertion (A)and Reason (R) are true, but Reason (R) is not the correct explanation of Assertion (A).
(c)If Assertion (A)is true, but Reason (R) is false.
(d)If both Assertion (A)and Reason (R) are false.

343. Assertion (A): Only a continuous change of magnetic flux will maintain an induced emf in a coil.
Reason (R) : An induced current has a direction such that the magnetic field due to the current opposes the change in the magnetic field that induces the current.

344. Assertion (A): At resonance the impedance of a series LCR circuit is Z = R.
Reason (R) : $Z = \sqrt{R^2 + (X_C - X_L)^2}$ and at resonance the inductive reactance (X_L) is equal to the capacitive reactance (X_C).

345. Assertion (A): When two coherent sources in Young's doubleslit experiment (YDSE) are infinitely close to each other, interference pattern is observed on a screen.
Reason (R): The fringe width in YDSE does not depend on separation between the two slits.

346. Assertion (A): A photon behaves as a particle.

Reason (R): A photon possesses both energy and momentum.

SECTION - B

347. A 20.0 cm long wire is connected across an ideal battery of 4 V. The drift velocity of conduction electrons in the wire is $0.8\ mm/s$. Calculate the relaxation time of the electrons.

348. (a)The real image of an object is formed at a distance twice the distance of the object from a concave mirror of focal length 10 cm . Find the distance between the object and the image.

OR

(b)An object is placed 1.50 m in front of a lens of power 4.0 D. Find the nature and position of the image formed.

349. Light of wavelength 700 nm is incident normally on a slit of width 0.2 mm. Find the angular width of the central maximum on a screen placed at a distance of 1 m from the slit.

350. The total energy of an electron in the hydrogen atom in the ground state is -13.6 eV . Find:
(a)the potential energy of the electron.
(b)the kinetic energy of the electron.
(c)the ratio of the magnitude of the total energy to the kinetic energy of the electron.

351. When the voltage across a p-n junction diode is increased from 0.90 V to 0.95 V , the diode current changes by 0.005 A . Find the dynamic resistance of the diode.

SECTION - C

352. (a)Define the terms 'emf' and 'terminal voltage' of a cell. Can the terminal voltage of a cell ever exceed its emf? Explain.

OR

(b)Define the term current density. Write its SI unit. Derive the equivalent form of Ohm's law $\vec{j} = \sigma\vec{E}$.

353. (a)Write one point of similarity and one point of difference between magnetic field and the electrostatic field.
(b)A wire of length l is first bent into a circular loop and then into a circular coil of two turns. For the same current passing through them, find the ratio of the magnetic fields at their centres.

354. (a)State the conditions under which total internal reflection occurs.
(b)A glass slab 3.0 cm thick, is placed over a dark ink dot. Find the height through which the image of the dot is raised. The refractive index of the glass is 1.5 .

355. (a)Explain how the reactance of a capacitor and that of an inductor change with the frequency of ac source.
(b)An ideal inductor of self-inductance 0.5 H is connected to an ac source of peak voltage 314 V and frequency 50 Hz. Calculate the peak value of current in the circuit.

356. (a)Write two characteristics of electromagnetic waves.
(b)What is meant by 'displacement current' ? Explain briefly how displacement current is set up during charging of a capacitor in a circuit.

357. State postulates of Bohr model of hydrogen atom. Using Bohr's second postulate, show that the circumference of n^{th} orbit in hydrogen atom is n times the de Broglie wavelength associated with the electron revolving in it.

358. (a)Define the term 'resistivity of a material'.
(b)Explain briefly how the resistivity of (i) is a metal and (ii) a semiconductor affected with the rise of temperature. Justify your answer.

SECTION - D

Question Numbers 29 and 30 are Case-Study based questions. Read the following paragraphs and answer the questions that follow:

359. A power supply is connected across the two plates of a capacitor. Consequently, one plate becomes positively charged and the other plate becomes negatively charged. Thus a uniform electric field is established between the two plates. If a charged particle is released between these two plates, it experiences a force. The potential difference between the plates affects its charge and the energy stored in the capacitor.

(i) A proton and an electron are released from rest in the space between the two plates of a charged capacitor. Assume that the proton and the electron do not interact with each other. The acceleration of the proton compared with that of the electron is
(a)same in both magnitude and direction.
(b)same in magnitude but in opposite direction.
(c)greater in magnitude and opposite in direction.
(d)lesser in magnitude but in opposite direction.
(ii) An electron is released between the two parallel plates of a charged capacitor. Which of the following statements is incorrect?
(a)The electric field between the plates is directed from the positively charged plate to the negatively charged plate.
(b)The magnitude of electric field is the same at all points between the plates.
(c)The acceleration of the electrons will be constant between the plates.
(d)The potential increases in the direction of the electric field between the plates.
(iii) The potential difference between the two plates of a capacitor is V. An electron of mass m and charge $-e$ is released from rest near the negative plate. The maximum speed gained by the electron is
(a) 2 eVm (b) $\sqrt{\frac{em}{2V}}$
(c) $\sqrt{\frac{2eV}{m}}$ (d) $\sqrt{\frac{2me}{V}}$
(iv) (a) The electric field between two parallel plates of a charged capacitor is $200\ \mathrm{V/m}$. The plates are 5 mm apart. The potential difference between the two plates is
(a) 20 V (b) 10 V
(c) 5.0 V (d) 1.0 V
OR
(b) A proton is located at a point between the above plates. The force acting on the proton is
(a) 1.6×10^{-19} N (b) 2×10^{9} N
(c) 3.2×10^{-17} N (d) 4×10^{9} N

360. **A photon is a quantum of energy. The energy of a photon depends on its frequency (v). When light of suitable frequency is incident on a metal surface, photo-electrons are emitted from the surface. The minimum frequency is called threshold frequency (v_0) and the minimum energy required to emit an electron is called the work function (ϕ_0) of that metal. The energy of an incident photon is utilised in two ways (i) liberating the electron and (ii) the remaining energy is given to the ejected electron as its kinetic energy i.e. $\mathrm{h}v = \phi_0 + \mathrm{K.E.}$**
(i) The packet of electromagnetic energy is called -
(a) Photon (b) Neutron
(c) Molecule (d) Quark
(ii) A photon has energy 3.3×10^{-19} J. Its momentum is -
(a) 9.9×10^{-11} kg. m/s
(b) 9.9×10^{-26} kg. m/s
(c) 1.1×10^{-27} kg. m/s
(d) 3.3×10^{-25} kg. m/s
(iii) Monochromatic light of frequency 5.0×10^{14} Hz is produced by a source. The power emitted is 3.315 mW . The number of photons emitted per second, on an average, by the source is -
(a) 5.0×10^{14} (b) 6.0×10^{15}
(c) 1.0×10^{16} (d) 2.0×10^{17}
(iv) (a) The work function of a metal is 2.14 eV . When light of frequency 6×10^{14} Hz is incident on the metal surface, photoemission of electrons occurs. The maximum kinetic energy of the emitted electrons is -
(a) 0.34×10^{-18} J (b) 0.40×10^{-17} J
(c) 0.51×10^{-18} J (d) 0.55×10^{-19} J
OR
(b) The work function of a metal is 2.21 eV . The threshold frequency for the metal is

(a) 2.1×10^{13} Hz (b) 3.2×10^{13} Hz
(c) 5.3×10^{14} Hz (d) 4.1×10^{15} Hz

SECTION-E

361. (a)(A) Two points charges q_1 and q_2 in air are located at $\vec{r}_1$ and $\vec{r}_2$ respectively in a region of uniform external field $\vec{E}$. Obtain an expression for the electrostatic potential energy of the system.

(B)The coulomb force between two point charges is 1.5×10^{-4} N. How will this force be affected in the following situations :

(i) the distance between the charges is doubled.

(ii) the magnitude of each charge is doubled but the distance between the charges remains the same.

OR

(b)(A) Differentiate between the electrostatic force and the gravitational force between two charged particles.

(B) A potential difference of 480 V is applied between two large horizontal plates, kept one above the other, 3.0 cm apart. A charged particle of mass 4×10^{-11} kg, when released at rest between the plates, remains stationary in the region. If the upper plate is at positive potential, find

(i) nature of the charge on the particle

(ii) the magnitude of the charge on the particle.

362. (a)(a)When a current passes through a conductor it produces a magnetic field.

(i) State the right-hand thumb rule that gives the direction of the magnetic field.

(ii) How does the magnetic field vary with the distance from the conductor?

(iii) Name the factors (other than the distance) which affect the magnitude of the magnetic field.

(b)Explain how a magnetic dipole in a uniform magnetic field attains (i) stable equilibrium (ii) unstable equilibrium.

OR

(b)(b) A particle of mass m and charge q is moving with velocity v in a circular path under the influence of a uniform magnetic field $\vec{B}$. Explain how will the path followed be affected when

(i) the strength of magnetic field is decreased.

(ii) the velocity of the particle is decreased.

(iii) the velocity of charged particle is such that one of its component is perpendicular to B and another component is parallel to $\vec{B}$.

(iv) an electric field is applied in such a way that electrostatic force balances the magnetic force on the charged particle.

(v) the magnetic field is suddenly removed.

In each of the above cases, other factors remain the same.

(b)Derive an expression for torque acting as a rectangular loop carrying a steady current when placed in a uniform magnetic field.

363. (a)(A) In Young's double slit experiment, the two slits are 0.15 mm apart. The slits are illuminated by a monochromatic light and an interference pattern is obtained a screen kept 3.0 m away from the slits. The distance between first and eighth minima is 8.0 cm. Find the wavelength of the light used.

(B)Two coherent waves of amplitude A_1 and A_2 are used in an interference experiment. Derive expression for the ratio of minimum and maximum intensities of light obtained in the interference pattern.

OR

(b)(A) A ray of light is incident at an angle of incidence, $\frac{A}{2}$ on face AB of a prism ABC of angle of prism A. The ray emerges normally from the opposite face AC. If the refractive index of the material of the prism be n, find the relation between A and n.

(B)The focal length of a convex lens of refractive index 1.5 is 20 cm. Find the focal length of this lens when immersed in a liquid of refractive index 1.25.