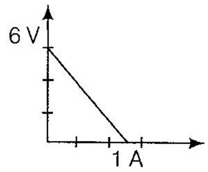
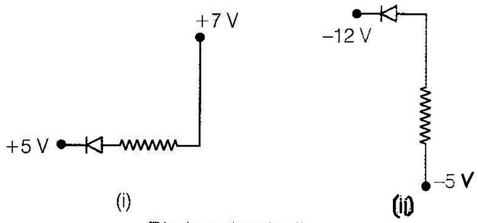
Very Very Important Questions along with their Solutions for Board Exams.
Physics

SECTION A
(*Each Question carries 1 Mark*)

1. The plot of the variation of potential difference across a combination of three identical cells in series versus current is as shown alongside. What is the emf of each cell?

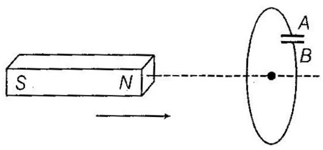


2. What is sky wave propagation?
3. Calculate the ratio of energies of photons produced due to transition of an electron of hydrogen atom from its, (i) second permitted energy level to the first level, and (ii) the highest permitted energy level to the first permitted level.
4. Write two important results drawn from Rutherford's alpha particle scattering experiment.
5. A carbon resistor is marked in coloured bands of red, black, orange and silver. What is the resistance and the tolerance value of the resistor?
6. Two charges of magnitudes –2Q and +Q are located at points (a, 0) and (4a, 0), respectively. What is the electric flux due to these charges through a sphere of radius 3a with its centre at the origin?
7. In the following diagrams, indicate whether the diodes are forward biased or reverse biased.



Diodes circuit diagrams

8. In the below figure, a bar magnet is quickly moved towards a conducting loop having a capacitor. Predict the polarity of the plates A and B of the capacitor.



As, the magnet moves towards the coil flux linked with the coil increases,
hence according to the Lenz's law it will oppose the change

As, the magnet moves towards the coil flux linked with the coil increases, hence according to the Lenz's law it will oppose the change.

SECTION B
(*Each Question carries 2 Marks*)

9. Give two disadvantages of transmitting AC over long distances at low voltage and high current.

10. A coil with an air core and an electric bulb are connected in series across a 220 V and 50 Hz AC source. The bulb glows with some brightness. How will the glow of the bulb be affected on introducing a capacitor in series, with the circuit? Justify your answer.

11. Sky waves are not used in transmitting TV signals, why? State two factors by which the range of transmission of TV signals can be increased.

12. (i) A circular coil of 30 turns and radius 8.0 cm carrying a current of 6.0 A is suspended vertically in a uniform horizontal magnetic field of magnitude 1.0 T. The field lines make an angle 60° with the normal of the coil. Calculate the magnitude of the counter torque that must be applied to prevent the coil from turning.

(ii) Would your answer change, if the circular coil were replaced by a planar coil of some irregular shape that encloses the same area? (All other particulars are also unaltered).

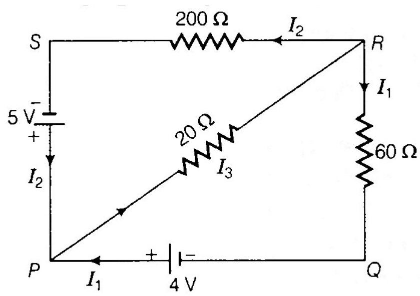
OR

Explain the following :

(i) Why do magnetic lines of force form continuous closed loops?

(ii) Why are the field lines repelled (expelled) when a diamagnetic materials is placed in an external uniform magnetic field?

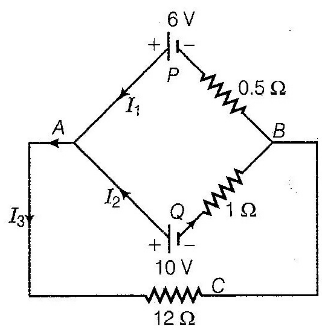
13. Apply Kirchhoff's laws to the loops *PRSP* and *PRQP* to write the expressions for the currents I_1, I_2 and I_3 in the given circuit.



Circuit diagram of loops

OR

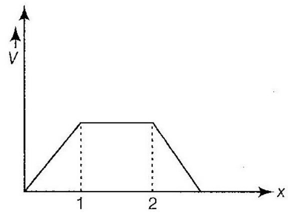
Apply Kirchhoff's laws to the loops ACBPA and ACBQA to write the expressions for the currents I_1, I_2, and I_3 in the network.



Circuit diagram of loops

14. Two wire loops *PQRS* formed by joining two semicircular wires of radii R_1 and R_2 carry a current, *i*. Find the magnetic field at the centre C.

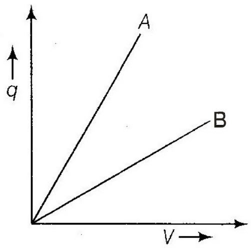
15. The electric potential, V as a function of distance (x) is shown in the figure. Construct a graph of the electric field strength, E versus distance x.



Graph electric potential *versus* distance

OR

The graph shows the variation of charge *q versus* potential difference V for two capacitors, C_1 and C_2. The two capacitors have the same plate separation but the plate area of C_2 is double than that of C_1. Which of the lines in the graph correspond to C_1 and C_2 and why?



Variation of charge versus potential

16. Write the type of biasing which is used in the following devices in their working.
(i) Photodiode (ii) Light emitting diode

17. Give reason.
(i) lighter elements are better moderators for a nuclear reactor than heavier elements.
(ii) In a natural uranium reactor, heavy water is referred moderator to ordinary water.

18. Write the truth table for the circuit shown in Figure (a) and (b) consisting of NOR gate only. Identify the logic operation (OR, AND, NOT) performed by the two circuits.

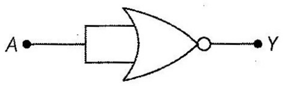


Fig. (a)

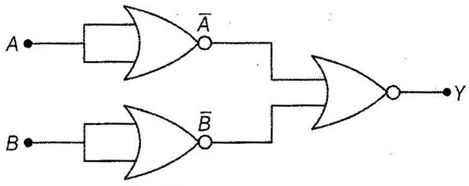


Fig. (b)

SECTION C
(*Each Question carries 3 Marks*)

19. A galvanometer can be converted into a voltmeter to measure up to
(i) V volt by connecting a resistance R_1 in series with coil.
(ii) $\frac{V}{2}$ volt by connecting a resistance R_2 in series with its coil.

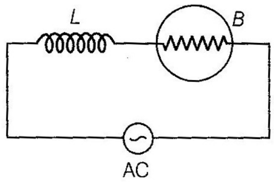
Find the resistance (R), in terms of R_1 and R_2 required to convert it into a voltmeter that can read up to 2V volts.

20. Two cells of emfs, 2E and E and internal resistances, 2r and r, respectively, are connected in parallel to each other and with an external resistance R. Obtain the expression for the equivalent emf and the internal resistance of the combination.

21. A circular coil of N turns and radius, R is kept normal to a magnetic field given by $B = B_0 \cos \omega t$. Deduce an expression for the emf induced in this coil. State the rule which helps to detect the direction of induced current.

OR

An inductor, L of reactance, X_L is connected in series with a bulb B to an AC source as shown in the figure. Briefly explain how does the brightness of the bulb change, when



AC source

(i) number of turns of the inductor is reduced?

(ii) A capacitor of reactance, $X_C = X_L$ is included in series in the same circuit?

22. (i) Why are coherent sources necessary to produce a sustained interference pattern?

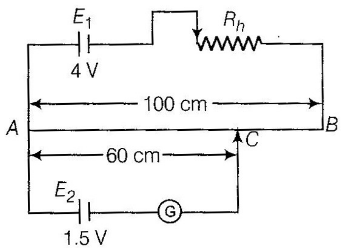
(ii) In Young's double slit experiment using monochromatic light of wavelength λ, the intensity of light at a point on the screen where path difference is λ, is K units. Find out the intensity of light at a point where path difference is $\lambda/3$.

23. An α-particle and proton are accelerated from the state of rest through the same potential difference, V. Find the ratio of de-Broglie wavelengths associated with them.

24. Draw the graph showing the variation of binding energy per nucleon with mass number. Give the reason for the decrease of binding energy per nucleon for nuclei with high mass numbers.

25. A convex mirror is placed in the path of a convergent beam so that the point of convergence of the beam lies on the principal axis at a distance of 30 cm behind the pole. The reflected rays converge in front of the mirror at a distance of 50 cm from the pole. What is the focal length of the mirror?

26. A battery E_1 of 4 V and a variable resistance R_h are connected in series with the wire AB of the potentiometer. The length of the wire of the potentiometer is 1m. When a cell of emf 1.5 V is connected between the points A and C, no current flows through E_2. Length of AC = 60 cm.



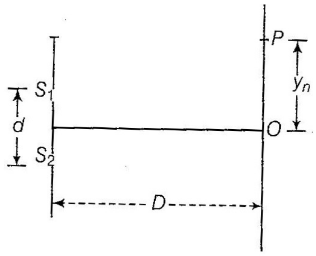
Potentiometer

(i) Find the potential difference between the ends A and B of the potentiometer.

(ii) Would the method work, if the battery E_1 is replaced by a cell of emf of 1 V?

27. Net capacitance of three identical capacitor in series is 1μF. What will be their net capacitance, if connected in parallel? Find the ratio fo energy stored in the two configurations, if they are both connected to the same source.

28. The intensity at the central maxima (O) in a Young's double slit experimental is I_0. If the distance OP equals one-third of fringe width of the pattern, then show that the intensity at point P would be $I_0/4$.



Young's double slit experiment

29. A 50 MHz sky wave takes 4.04 ms to reach a receiver *via* re-transmission from a satellite 600 km above Earth's surface. Assuming re-transmission time by satellite negligible, find the distance between source and receiver. If communication between the two was to be done by Line of Sight (LOS) method, what should size and placement of receiving and transmitting antennas be?

30. (a) If a neutron and alpha particle having same linear momentum, then which has larger wavelength?

(b) What is the shortest wavelength present in the Paschen series of spectral lines in hydrogen atom?

31. Derive an expression for the magnetic dipole moment of an electron revolving around a nucleus in terms of Planck's constant (h) and mass of electrons (m_e).

32. Using the data given below, state which two of the given lenses will you prefer to construct a best possible

(i) telescope (ii) microscope.

Also, indicate which of the selected lenses is to be used as an objective and as an eye lens in each case.

Lens	Power (P)	Aperture (A)
L_1	6 D	1 cm
L_2	3 D	8 cm
L_3	10 D	1 cm

33. A beam of light consisting of two wavelengths 650 nm and 520 nm, is used to obtain interference fringes in Young's double slit experiment.

(a) Find the distance of the third bright fringe on the screen from the central maximum for the wavelength 650 nm.

(b) What is the least distance from the central maximum where the bright fringes due to both wavelength coincide?

The distance between the two slits is 2 mm and the distance between the plane of the slits and the screen is 120 cm.

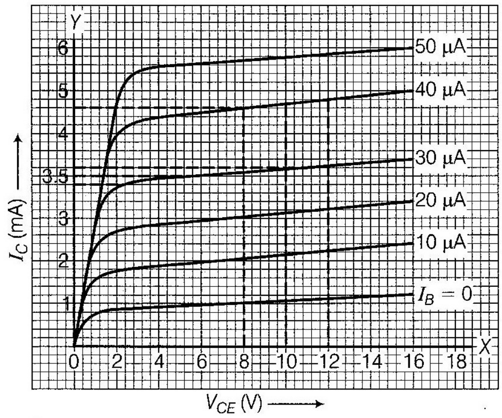
34. What is a Zener diode? How can a Zener diode be used as voltage regulator? Explain using appropriate circuit diagram.

35. Output characteristics of an n-p-n transistor in CE configuration is shown in the below figure.

Determine :

(a) DC current gain (b) Dynamic output resistance

(c) AC current gain at an operating point, $V_{CE} = 10\,V$, when $I_B = 30\mu A$.



36. An electron emitted by a heated cathode and accelerated through a potential difference of 2.0 kV, enters of region with a uniform magnetic field of 0.15 T. Determine the trajectory of the electrons if the magnetic field (i) is transverse to its initial velocity, (ii) makes an angle 30° with the initial velocity.

37. A horizontal straight wire 10 m long extending from East to West is falling with a speed of 5 m/s at right angles to the horizontal component of the earth's magnetic field 0.30×10^{-4} Wbm^{-2}.

(i) What is the instantaneous value of the emf induced in the wire?

(ii) What is the direction of the emf?

(iii) Which end of the wire is at the higher electrical potential?

38. What is an astronomical telescope? Draw the labeled ray diagram, when final image forms at least distance of distinct vision. Deduce expression for magnifying power.

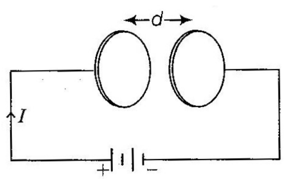
39. Sketch the graph, showing the variation of stopping potential with frequency of incident radiation for two photosensitive metals A and B having threshold frequencies v_0' and v_0' respectively ($v_0' > v_0$).

(i) Which of the two metals, A or B has higher work function?

(ii) What information do you get from the slope of the graphs?

(iii) What does the value of the intercept of graph on the potential axis represent?

40. A capacitor made of two circular plates each of radius, r = 12 cm and charging current is constan, t I = 0.15 A.



(i) Calculate the rate of change of electric field between the plates.

(ii) Find the displacement current across the plates.

(iii) Is Kirchhoff's first rule valid at each plate of capacitor? Explain.

41. A 200 V variable frequency AC source is connected to a series combination of L = 5H, C = 80 μF and R = 40 Ω. Calculate

(i) angular frequency of source to get the maximum current in the circuit.

(ii) current amplitude at resonance.

(iv) power dissipation in the circuit.

42. In the accompanying diagram, the direct image is formed by the lens (f = 10 cm) of an object placed at O and that formed after reflection from the spherical mirror is formed at the same point O'. What is the radius of curvature of the mirror?

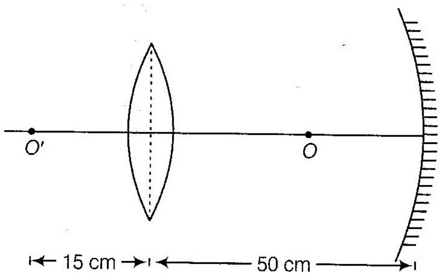
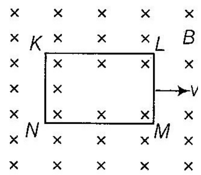


Image formed by the lens

43. A rectangular loop shaped wire KLMN is moved with a uniform velocity, v at right angle to a uniform magnetic field, B as shown in the figure.



(i) What is the magnitude of current induced in the loop?

(ii) Will there be any work done by the loop? Give reason for your answer.

SECTION D
(*Each Question carries 4 Marks*)

44. Merrie Curie and her teacher turned husband Pierre Curie worked hard to extract radium chloride ($RaCl_2$) from uranium ore. They succeed in 1902 after a long struggle. About 0.19 g of $RaCl_2$ was extracted and its radioactivity was studied. They were awarded by the nobel prize, which they shared it with Henri Becquerel.

(i) What are the values shown by Merrie Curie and her husband?

(ii) What do you understand by radioactivity? How the half-life period is related to the disintegration constant?

(iii) The sequence of stepwise decays of a radioactive nucleus is

$$D \xrightarrow{\alpha} D_1 \xrightarrow{\beta^-} D_2 \xrightarrow{\alpha} D_3$$

If the nucleon number and atomic number of D_2 are 176 and 71, respectively, then what are the corresponding values of and D_3? Justify your answer in each case.

SECTION E
(*Each Question carries 5 Marks*)

45. An inductor L, a capacitor C and a resistor R are connected in series in an AC circuit. Deduce with the help of suitable phasor diagram, a mathematical expression for impedance of this circuit. What is meant by resonance of this circuit? Prove that this circuit exhibits resonance at a frequency given by $\frac{1}{2\pi\sqrt{LC}}$.

OR

(i) A series L-C-R circuit is connected to an AC source of voltage V and angular frequency ω when only the capacitor is removed, the current lags behind the voltage by a phase angle 'ϕ' and when only the inductor is removed, the current leads the voltage by the same phase angle. Find the current flowing and the average power dissipated in the L-C-R circuit.

(ii) An alternating voltage given by V = 140 sin 314 *t* is connected across a pure resistor of 50 π. Find

(a) The frequency of the source (b) the rms current through the resistor.

46. Show that the refractive index of the material of a prism is given by

$$\mu = \frac{\sin\frac{(A+\delta_m)}{2}}{\sin\left(\frac{A}{2}\right)}$$

Where, the symbols have their usual meanings.

OR

Define the term resolving power of an astronomical telescope. How does it get affected on

(i) Increasing the aperture of the objective lens?

(ii) Increasing the wavelength of light used?

(iii) Increasing the focal length of the objective lens?

47. Find an expression for the torque acting on and electric dipole placed in uniform electric field. A system of two charges $q_A = 2.5\times10^{-7}$ C and $q_B = -2.5\times10^{-7}$ C located at points A (0, 0, –15) cm and B (0, 0, +15) cm, respectively. Find the electric dipole moment of the system and the magnitude of the torque acting on it, when it is placed in a uniform electric field 5×10^{4} NC^{-1}, making an angle 30°.

OR

A capacitor of capacitance C is charged fully by connecting it to a battery of emf E. It is then disconnected from the battery. If the separation between the plates of the capacitor is now doubled, what will happen to

(i) Charge stored by the capacitor? (ii) Potential difference across it?

(iii) field strength between the plates? (iv) energy stored by the capacitor?

(iv) capacitance of the capacitor?

48. Explain the principle, working and theory of a transformer by using its diagram. Also, explain the use of transformer in long distance transmission of electric power with the help of schematic diagram.

OR

(a) Mention the reasons for energy losses in an actual transformer.

(b) The power transmission lines needs input power at 2300 V to a step down transformer with its primary windings having 4000 turns. What should be the number of turns in the secondary windings in order to get output power at 230 V.

49. (i) What do you mean by current sensitivity of a moving coil galvanometer. On what factor does it depend?

(ii) State two reason why a galvanometer cannot be used as such to measure high order current in a given circuit?

(iii) The current sensitivity of a moving coil galvanometer is 5 division/mA and voltage sensitivity is 20 division/volt. Find the resistance of the galvanometer.

OR

(i) Write any three characteristics, a ferromagnetic substance should possess, if it is to be used to make a permanent magnet. Give one example of such a material.

(ii) The susceptibility of a magnetic material is –0.085. Identify the magnetic type of the material.

(iii) A Rowland ring of mean radius 15 cm has 3500 turns of wire wound on a ferromagnetic core of relative permeability 800. What is the magnetic field (B) in the core for a magnetizing current of 1.2 A?

SOLUTIONS

1. In open circuit, when no current is being drawn from the cells, the terminal potential difference is equal to emf of cells.

$\therefore$ Emf of the series combination of three cells = 6V

$\therefore$ Emf of each cell, $\varepsilon = \frac{6V}{3} = 2V$

2. A radiowave of frequency range 2 MHz to 20 MHz can be directed towards the sky and reflected by the ionosphere towards desired location of the Earth, called as sky wave propagation.

3. Energy of photon $hv\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ $\quad \therefore \frac{(hv)_{2\to1}}{(hv)_{\infty\to1}} = \frac{\left(\frac{1}{1^2} - \frac{1}{2^2}\right)}{\left(\frac{1}{1^2} - \frac{1}{\infty^2}\right)} = \frac{3}{4} = 3:4$

4. (i) The most of the mass and the entire positive charge of an atom is concentrated in a very small volume of the atom, called nucleus.

(ii) The nuclear radius is about 1/10000 of the atomic radius.

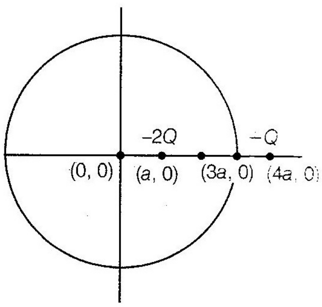
5. According to colour code of carbon resistor, a carbon resistance of bands of red and black having figures 2 and 0. The third band of orange having multiplier 10^3.

$\therefore$ The value of resistance is given by $R = 20 \times 10^3 \Omega$

But the fourth band having silver colour which represents a tolerance of ±10%.

Hence, the value of carbon resistor, $R = 20 \times 10^3 \Omega \times \pm 10\%$

6. Gauss's theorem states that the total electric flux linked with closed surface, S is $\phi_E = \phi E.dS = \frac{q}{\varepsilon_0}$, where, q is the total charge enclosed by the closed Gaussian (imaginary) surface.



The sphere enclose charge = – 2Q + Q = – Q. Therefore, $\phi = \frac{Q}{\varepsilon_0}$.

7. (i) Forward biased, because p-side is at higher potential (+7 V) then n-side (+5 V).

(ii) Forward biased, because p-side is at higher potential (–5 V) than n-side (–12 V).

8. Here, the North pole is approaching the magnet, so the induced current in the face of loop viewed from left side will flow in such a way that it will behave like North pole, so, South pole developed in loop when viewed from right hand side of the loop. The flow of induced current is clockwise. Hence, A acquires positive polarity and B acquires negative polarity.

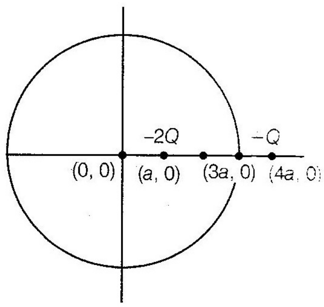
9. Following are the disadvantages of transmitting electrical power at low voltage.

(i) Large lengths of transmission cables have sufficient resistance. Hence, a large amount of energy (I^2Rt) will be lost as heat during transmission.

(ii) Large voltage drop (IR) occurs along the line wire. Hence, the voltage at the receiving station will be much smaller than that at the generating station.

10. A coil with an air core has very small inductance and therefore, inductive reactance, $X_L \approx 0$. When a capacitor is introduced in series, the impedance becomes $Z = \sqrt{R^2 + X_C^2}$, which is greater than R.

On increasing impedance of the circuit, the current in the circuit reduces $\left(\because\ i = \frac{V}{Z}\right)$ and the brightness of the bulb decrease.



The sphere enclose charge = − 2Q + Q = − Q

Therefore, $\phi = \frac{Q}{\varepsilon_0}$.

11. TV signals have a frequency of 100 to 220 MHz which cannot be reflected by the ionosphere. So, transmission of TV signals via sky wave is not possible.
Range of TV transmission can be increased by using
(i) Tall antenna (ii) Geostationary satellites

12. Here, $N = 30$, $R = 8.0\text{ cm} = 8 \times 10^{-2}\text{ m}$,

$I = 6.0\text{ A}$, $\theta = 60°$ and $B = 1.0\text{ T}$

(i) $\therefore$ The magnitude of the counter torque = magnitude of the deflecting torque

$$= NAIB\sin\theta = N.(\pi R^2)\,IB\sin\theta = 30 \times 3.14 \times (8 \times 10^{-2})^2 \times 6.0 \times 1.0 \times \sin 60° = 3.14\text{ Nm}$$

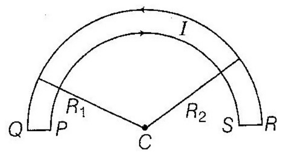
(ii) The answer would not change as area enclosed by the coil as well as all other particular remain unaltered and the formula, $\tau = NAIB\sin\theta$ is true for planar coil for any shape.

13. Apply Kirchhoff's 1st law at point P of the circuit $I_3 = I_2 + I_1$

Applying Kirchhoff's 2nd law to loop PRSP $-20I_3 - 200I_2 + 5 = 0$, $40I_2 + 4I_3 = 1$

Applying Kirchhoff's 2nd law to loop PRQP $-20I_3 - 60I_1 + 4 = 0$, $15I_1 + 5I_3 = 1$

14. Let $\hat{n}$ be the unit vector perpendicular to the plane of paper outwards. Magnetic field at C due to current through the entire structure PQRS is

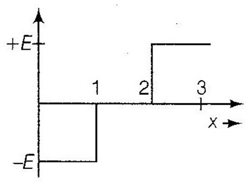


$$B = B_{SR} + B_{RQ} + B_{QP} + B_{PS} = 0 + \frac{\mu_0}{4\pi}\frac{\pi I}{R_1}\hat{n} + 0 + \frac{\mu_0}{4\pi}\frac{\pi I}{R_2}(-\hat{n}) \quad \ldots(i)$$

$$B = \frac{\mu_0 I}{4}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)\hat{n} \quad B = \frac{\mu_0 I}{4}\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \text{ upwards}$$

15. Electric field intensity 'E' and electric potential 'V' are related as $E = -\frac{dV}{dx}$, where x is distance. So negative slope of V versus x graph will give the value of electric field.

Graph of the electric field strength, E versus distance x is given below.



Electric field strength versus distance

$\because$ Electric field intensity and electric potential are related as $E = \frac{-dV}{dx}$ = Negative slop of V – x graph.

Here, when $0 > x > 1$, slope is positive.

Then, $\frac{dV}{dx} > 0$

$\therefore$ Electric field intensity is constant = – E; For $1 < x < 2$ slope = 0 $\Rightarrow$ E = 0

For $2 < x < 3$, $\frac{dV}{dx} < 0 \Rightarrow$ Electric field, $E > 0$ i.e. E = + ve = + E

OR

$\because$ $C = \frac{q}{V}$ [C is capacitance, q is charge on capacitor and V is potential]

So, slope of q versus V graph will give capacitance, also we know that, $C = \frac{\varepsilon_0 A}{d}$

[ε_0 is permittivity of free space, A is area of plate of capacitor, d is distance between plates of capacitor]

The slope of graph $= \frac{q}{V} = C$ (capacitance of capacitor)

Also,

$\because$ d is a constant.

$\therefore$ $C \propto A$

$\Rightarrow$ slope of graph $\propto$ A (area of plate)

$\Rightarrow$ Higher the area of plates of capacitor = Higher the slope of graph.

So, graph A represents C_2 and graph B represents C_1.

16. (i) Photodiode is used in reverse biasing.

(ii) Light Emitting Diode (LED) is used in forward biasing.

17. (i) A moderator slows down fast neutrons released in a nuclear reactor. The basic principle of mechanics is that the energy transfer in a collision is the maximum when the colliding particles have equal masses. As, lighter elements have mass close to that of neutrons, lighter elements are better moderators than heavier elements.

(ii) Ordinary water has hydrogen nuclei $\left({}_1^1H\right)$ which have greater absorption capture for neutrons; so ordinary water will absorb neutrons rather than slowing them. On the other hand, the heavy hydrogen nuclei $\left({}_1^2H\right)$ have negligible absorption capture for neutrons, so they share energy with neutrons and neutrons are slowed down.

18. The logic operation of fig. (a) is $Y = \overline{A + A} = \overline{A}$.

This is logic operation of NOT gate. The truth table of this circuit is

A	$Y = \overline{A}$
0	1
1	0

The logic operation of Fig. (b) is $Y = \overline{\overline{A} + \overline{B}} = \overline{\overline{A}}.\overline{\overline{B}} = A.B$

The truth table of this circuit is

A	B	Y
0	0	0
1	0	0
0	1	0
1	1	1

19. Formula for conversion of galvanometer into voltmeter is

$$i_g = \frac{V}{R + G}$$

Where, G is galvanometer resistance.

In case (i) $\quad i_g = \dfrac{V}{R_1 + G} \quad \ldots(i)$

In case (ii), $\quad i_g = \dfrac{V/2}{R_2 + G} \quad \ldots.(ii)$

From Eqs. (i) and (ii), we get

$$\frac{V}{R_1 + G} = \frac{V}{2(R_2 + G)} \Rightarrow R_1 + G = 2R_2 + 2G$$

$$G = R_1 - 2R_2 \quad \ldots(iii)$$

For conversion of galvanometer into a voltmeter of range 2V, we have

$$i_g = \frac{2V}{R+G} \quad \text{.... (iv)}$$

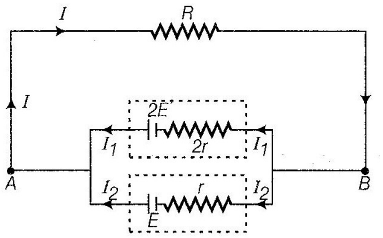
From Eqs. (i) and (iv), we get $\frac{V}{R_1+G} = \frac{2V}{R+G}$

$R + G = 2R_1 + 2G \Rightarrow R = 2R_1 + G$

Putting the value of G from Eq. (iii), we get

$R = 2R_1 + (R_1 - 2R_2) \Rightarrow R = 3R_1 - 2R_2$

20. Suppose, the cell combination is connected with resistance R (say) as shown in figure below.



Circuit diagram

Applying Kirchhoff's first law.

$$I = I_1 + I_2 \quad \text{.....(i)}$$

Applying KVL rule, $2E - IR - I_1(2r) = 0$

$\Rightarrow \quad IR = 2E - 2I_1r \quad$ ....(ii)

Again applying KVL rule,

$E - IR - I_2r = 0$

Or $IR = E - I_2r$ ... (iii)

Or $IR = E - (I - I_1)r$ [from Eq. (i)]

Or $IR = E - Ir + I_1r$

Or $IR + Ir = E + I_1r$

Or $I(R + r) = E + I_1r$ ...(iv)

Multiplying Eq. (iv) by 2 and adding with Eq. (ii), we get

$2I(R + r) + IR = (2E - 2I_1r) + (2E + 2I_1r)$

Or, $3IR + 2Ir = 4E$

Or, $I(3R + 2r) = 4E$

Or $I = \frac{4E}{3\left(R + \frac{2r}{3}\right)}$

Or, $I = \dfrac{\left(\dfrac{4E}{3}\right)}{R + \dfrac{2r}{3}}$ ...(v)

If equivalent emf and internal resistance of a battery be E_{eq} and r_{eq}, then current

$I = \dfrac{E_0}{R + r_0}$ ...(vi)

Comparing Eqs. (v) and (vi) we get

Equivalent emf, $E_{eq} = \dfrac{4E}{3}$ volt

Internal resistance, $r_{eq} = \dfrac{2r}{3}\Omega$

21. Induced emf in the coil

$e = -N\dfrac{d\phi}{dt} = -N\dfrac{d}{dt}(BA\cos 0°)$ $[\because \phi = BA\cos\theta]$

$= -NA\dfrac{dB}{dt}$ $[\because \cos 0° = 1]$

$= -N\pi R^2\dfrac{d}{dt}(B_0 \cos \omega t)$ $[\because A = \pi R^2]$

$= N\pi R^2 \omega B_0 \sin \omega t$ $[\because \dfrac{d}{dt}\cos \omega t = -\omega \sin \omega t]$

The direction of induced current is given by Lenz's law which states, the direction of induced current is always in such a way that it opposes the cause due to which it is produced.

OR

(i) When the number of turns of the inductor is reduced, its inductance, X_L decreases. A decrease in inductance causes the current in the circuit to increase and hence, the brightness of the bulb increases.

(ii) When the capacitor is connected in series in the circuit, then its impedance is given by

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

Here, $X_L = X_C$

$\therefore$ $X_L = X_C$

$Z = R$

Thus, the impedance is minimum and is equal to the resistance and hence, the brightness of the bulb is maximum.

22. (i) Coherent sources produces light of constant phase difference and hence permanent fringe pattern produces due to interference of light.

(ii) Intensity of light at a point on the screen is given by

$$I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$$

(a) For the path difference of λ, phase difference is 2π. As, source are coherent and taken out L of the same source in Young's double slit experiment,

$I_1 = I_2 = I$

$I_R = 2I + 2I\cos 2\pi$

$I_R = 4I$

$4I = v$ unit ....(i)

(b) Path difference of $\frac{\lambda}{3}$ corresponds to phase difference $\frac{2\pi}{3}$

$I_R = 2I + 2I\cos\frac{2\pi}{3} = 2I - I = I$ ....(ii)

From Eqs. (i) and (ii) we get

$I_R = \frac{K}{4}$ units

23. de-Broglie wavelength, $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE_k}}$, where p is momentum and E_k is kinetic energy of a particle.

For charged particle accelerated through a potential difference V, kinetic energy of particle $E_k = qV$

$\therefore$ de-Broglie wavelength, $\lambda = \frac{h}{\sqrt{2mqV}}$

For α – particle, $m = 4m_p, q = 2e$

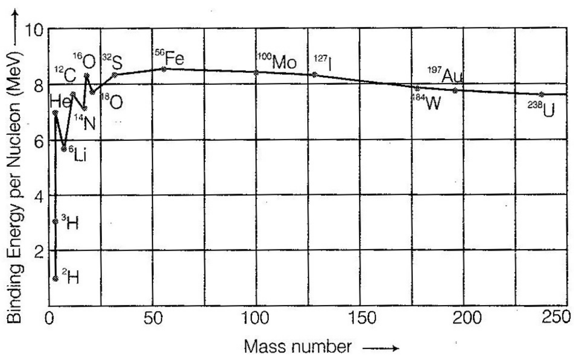
$\therefore \quad \lambda_\alpha = \frac{h}{\sqrt{2 \times 4m_p \times 2eV}} = \frac{h}{4\sqrt{m_p eV}}$

For proton, $m = m_p, q = e,$

$\therefore \quad \lambda_p = \frac{h}{\sqrt{2m_p eV}}$

$\therefore$ Ratio of de-Broglie wavelengths, $\frac{\lambda_\alpha}{\lambda_p} = \frac{1}{\sqrt{8}} \Rightarrow \lambda_\alpha : \lambda_p = 1 : 2\sqrt{2}$

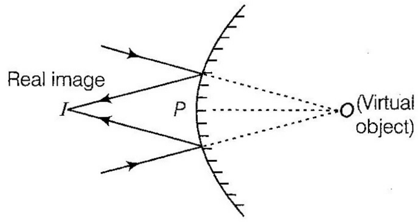
24.



Graph showing the variation of binding energy per nucleon

Reason : Due to increase in coulomb repulsive force between protons, binding energy per nucleon deceases for nuclei with higher mass numbers.

25. We have distance of object from mirror, u = (+) 30 cm Distance of image from mirror, v = (–) 50cm



Reflected rays converge in front of the mirror

From mirror formula $\frac{1}{v}+\frac{1}{u}=\frac{1}{f} \Rightarrow \frac{1}{-50}+\frac{1}{30}=\frac{1}{f}$ or focal length of the mirror, f = + 75 cm.

26. (i) We know that, $\frac{E_2}{E'}=\frac{l}{l'}$

Here, $E_2 = 1.5\text{ V}, l = 60\text{ cm}, l' = 100\text{ cm}$

$\therefore$ Potential difference, $E' = E_2 \times \frac{l'}{l} = 1.5\text{V} \times \frac{100}{60} = \frac{150}{60}\text{ V} = 2.5\text{ V}$

The potential difference between the ends A and B of the potentiometer is 2.5 V.

(ii) No, the method will not work because if the battery E_1 is replaced by a cell of emf of 1 V in that case, then the balance point or deflection point will not be obtained.

27. If n identical capacitors, each of capacitance, C are connected in series combination gives equivalent capacitance,

$$C_s = \frac{C}{n}$$

And when connected in parallel, then equivalent capacitance.

$$C_p = nC \Rightarrow \frac{C_p}{C_s} = \frac{nC}{C/n} = n^2$$

Or $$C_p = n^2 C_s$$

Also, for same voltage, energy stored in capacitor is given by

$$U = \frac{1}{2}CV^2 \qquad \text{[for V = constant]}$$

According to problem,

$C = nC_s$

$= 3 \times 1\mu F = 3\mu F$

For each capacitor, in parallel combination,

$C_p = nC = 3 \times 3 = 9\mu F$ or $C_p = 9\mu F$

For same voltage,

$$U \propto C \Rightarrow \frac{U_s}{U_p} = \frac{C_s}{C_p} = \frac{C/n}{nC} = \frac{1}{n^2} = \frac{1}{(3)^2} = \frac{1}{9} \Rightarrow \frac{U_s}{U_p} = \frac{1}{9} \text{ or } U_s : U_p = 1:9$$

28. Intensity can be found out, if we know the phase difference. Phase difference can be calculated with the help of path difference. So, first of all path difference will be calculated.

Given, $OP = Y_n$

The distance OP equals one-third of fringe width of the pattern,

i.e. $$Y_n = \frac{\beta}{3} = \frac{1}{3}\left(\frac{D\lambda}{d}\right) = \frac{D\lambda}{3d} \Rightarrow \frac{dy_n}{D} = \frac{\lambda}{3}$$

Path difference $= S_2P - S_1P = \frac{dY_n}{D} = \frac{\lambda}{3}$

$\therefore$ Phase difference, $\phi = \frac{2\pi}{\lambda} \times \text{path difference}$

$$= \frac{2\pi}{\lambda} \times \frac{\lambda}{3} = \frac{2\pi}{3}$$

If intensity at central fringe is I_0, then intensity at a point P, where phase difference is ϕ, is given by

$$I = I_0 \cos^2 \phi$$

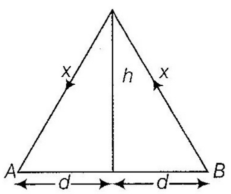
$$\therefore \quad I = I_0 \left(\cos\frac{2\pi}{3}\right)^2$$

$$= I_0 \left(-\cos\frac{\pi}{3}\right)^2$$

$$= I_0 \left(-\frac{1}{2}\right)^2 = \frac{I_0}{4}$$

Hence, the intensity at the point P would be $\frac{I_0}{4}$.

29. Let the receiver be at point A and source be at B.



Re-transmission from a satellite

Velocity of waves $= 3 \times 10^8$ m/s

Time to reach a receiver $= 4.04$ ms $= 4.04 \times 10^{-3}$ s

Let the height of satellite is $h_s = 600$ km

Radius of Earth = 6400 km

Size of transmitting antenna = h_T

We know that,

$$\frac{\text{Distance travelled by wave}}{\text{Time}} = \text{velocity of waves}$$

$$\frac{2x}{4.04\times10^{-3}} = 3\times10^{8}$$

Or $$x = \frac{3\times10^{8}\times4.04\times10^{-3}}{2}$$

$$= 6.06\times10^{5}$$

$$= 606 \text{ km}$$

Using Pythagoras theorem, $d^2 = x^2 - h_s^2 = (606)^2 - (600)^2 = 7236$ or $d = 85.06$ km

So, the distance between source and receive $= 2d = 2\times85.06 = 170$ km

The maximum distance covered on ground from the transmitter by emitted EM waves, $d = \sqrt{2Rh_T}$

Or $$\frac{d^2}{2R} = h_T$$

or size of antenna, $h_T = \frac{7236}{2\times6400} = 0.565 \text{ km} = 565 \text{m}$

30. (a) Since, $\lambda = \frac{h}{p}$

Where, $\lambda =$ wavelength

$h =$ Planck's constant

and $p =$ linear momentum

As both particles have same linear momentum, therefore both particles have same wavelength.

(b) The wavelength in Paschen series is given by $\frac{1}{\lambda} = R\left[\frac{1}{3^2} - \frac{1}{n^2}\right]$

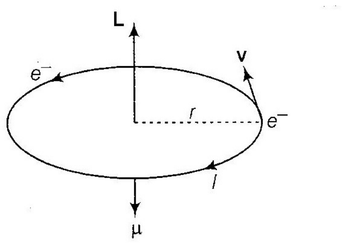
Where, R = Rydberg constant and n = 4, 5, 6, …..

For shortest wavelength $n = \infty$

$$\therefore \frac{1}{\lambda} = R\left[\frac{1}{(3)^2} - \frac{1}{\infty^2}\right] \Rightarrow \frac{1}{\lambda} = \frac{R}{(3)^2} \text{ or } \lambda = \frac{(3)^2}{R} = \frac{9}{1.097\times10^{7}}$$

Shortest wavelength $\lambda = 8.204\times10^{-7}\text{m}$ or $\lambda = 8204$ Å

31. Let an electron revolves around the nucleus with uniform speed v. This motion is equivalent to electric current loop of magnetic dipole moment.



Magnetic moment of a revolving electron

$\mu = IA = I(\pi r^2) = \pi I r^2$ ....(i)

Let t be the time period of electron.

Therefore, $T = \frac{2\pi r}{V}$ ....(ii)

Where, r is the radius of circular path of electron. Now, the equivalent current

$I = \frac{e}{T} = \frac{e}{\left(\frac{2\pi r}{v}\right)}$ [from Eq. (ii)]

$I = \frac{ev}{2\pi r}$ ...(iii)

$\therefore$ Magnetic dipole moment

$\mu = \pi I r^2 = \pi\left(\frac{ev}{2\pi}\right)r^2$ [from Eq. (iii)]

$\mu = \frac{evr}{2}$ ...(iv)

Now, the angular momentum of electron

$L = m_e vr$ ... (v)

$\Rightarrow \quad \frac{\mu}{L} = \frac{\left(\frac{evr}{2}\right)}{(m_e vr)} = \frac{e}{2m_e}$ or $\mu = \left(\frac{e}{2m_e}\right)L$ ...(vi)

By Bohr's second postulate of quantization,

Angular momentum, $L = \frac{nh}{2\pi}$ where, n = 1, 2, 3 .... And h = Plank's constant

$\therefore$ From Eq. (vi) $\mu = \left(\frac{e}{2\,m_e}\right)\left(\frac{nh}{2\pi}\right)$

Magnetic dipole moment $\mu = n\left(\frac{eh}{4\pi m_e}\right)$

This is the required expression.