Class XII Session 2026-27
Subject - Physics
Sample Question Paper - 5

Time Allowed: 3 hours **Maximum Marks: 70**

General Instructions:

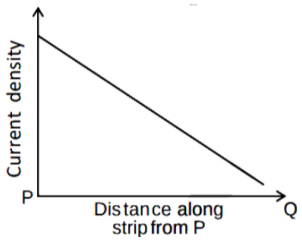
1. There are 33 questions in all. All questions are compulsory.
2. This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
3. All the sections are compulsory.
4. **Section A** contains sixteen questions, twelve MCQ and four Assertion Reasoning based of 1 mark each, **Section B** contains five questions of two marks each, **Section C** contains seven questions of three marks each, **Section D** contains two case study based questions of four marks each and **Section E** contains three long answer questions of five marks each.
5. There is no overall choice. However, an internal choice has been provided in one question in Section B, one question in Section C, one question in each CBQ in Section D and all three questions in Section E. You have to attempt only one of the choices in such questions.
6. Use of calculators is not allowed.

Section A

1. The potential barrier in the depletion layer is due to **[1]**

   a) Holes
   b) Forbidden gap
   c) Electrons
   d) Ions

2. An electric current flows along an insulated strip PQ of a metallic conductor. The current density in the strip varies as shown in the graph. Which one of the following statements could explain this variation? **[1]**



   a) The strip is narrower at Q than at P
   b) The potential gradient along the strip is uniform
   c) The resistance per unit length of the strip is constant
   d) The strip is narrower at P than at Q

3. The relationship between angle of incidence i, prism of angle A and angle of minimum deviation for a triangular prism is **[1]**

a) $2A + \delta_m = i$ b) $A + \delta_m = 2i$

c) $A + \frac{\delta_m}{2} = i$ d) $A + \delta_m = i$

4. The magnetic moment has dimensions of **[1]**

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

c) $[LT^{-1}A]$ d) [LA]

5. In electrolytic capacitors positive terminal is **[1]**

a) one on which aluminium oxide film is not formed b) none of the these

c) one on which aluminium oxide film is formed d) either of the two terminals

6. A galvanometer can be changed into an ammeter by providing: **[1]**

a) high resistance in parallel b) low resistance in series

c) low resistance in parallel d) high resistance in series

7. A moving conductor coil produces an induced emf. This is in accordance with: **[1]**

a) Coulomb's law b) Ampere's law

c) Lenz's law d) Faraday's law

8. The arrangement fo two magnetic poles of equal and opposite strengths separated by a finite distance is called: **[1]**

a) Magnetic dipole b) Magnetic current

c) Magnetic pole d) Magnetic field

9. Which out of the following, cannot produce two coherent sources? **[1]**

a) Prism b) Fresnel briprism

c) Young's double slit d) Lloyd's mirror

10. A half ring of radius R has a charge per unit length equal to λ. The field at the center is **[1]**

a) zero b) $\frac{2\lambda}{4\pi\varepsilon_0 R}$

c) $\frac{\lambda}{4\pi\varepsilon_0 R}$ d) $\frac{3\lambda}{4\pi\varepsilon_0 R}$

11. In the given Fig., V_0 is the potential barrier across a p-n junction, when no battery is connected across the junction **[1]**



a) 3 and 1 both correspond to reverse bias of junction.

b) 3 corresponds to forward bias of junction and 1 corresponds to reverse

bias of junction

c) 1 corresponds to forward bias and 3 corresponds to reverse bias of junction.

d) 1 and 3 both correspond to forward bias of junction

12. The magnifying power of the telescope can be increased by **[1]**

a) increasing the distance of an object

b) fitting eye-piece of low power

c) increasing the focal length of eyepiece

d) fitting eye-piece of high power

13. **Assertion (A):** An electron and a photon possessing same wavelength, will have the same momentum. **[1]**

Reason (R): Electron and photon possess same energy.

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

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

c) A is true but R is false.

d) A is false but R is true.

14. **Assertion (A):** No work is done in taking a positive charge from one point to another inside a positively charged metallic sphere while outside the sphere work is done in taking the charge towards the sphere. **[1]**

Reason (R): Inside the sphere electric potential is the same at each point, but outside it is different for different points.

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

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

c) A is true but R is false.

d) A is false but R is true.

15. **Assertion (A):** Diffraction is common in sound but not common in light waves. **[1]**

Reason (R): The wavelength of light is more than the wavelength of sound.

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

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

c) A is true but R is false.

d) A is false but R is true.

16. **Assertion:** The resistance offered by an inductor in a DC circuit is always constant. **[1]**

Reason: The resistance of the inductor in steady-state is zero.

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

b) Both A and R are true but R is NOT the correct explanation of A

c) A is true but R is false

d) A is false and R is also false

Section B

17. **[2]**

a. Which one of the following electromagnetic radiations has least frequency: UV radiations, X-rays, Microwaves?

b. How do you show that electromagnetic waves carry energy and momentum?

c. Write the expression for the energy density of an electromagnetic wave propagating in free space.

18. Determine the number density of donor atoms which have to be added to an intrinsic germanium semiconductor to produce an n-type semiconductor of conductivity 5 Ω^{-1} cm^{-1}, given that the mobility of electron in n-type Ge is 3900 cm^2 /Vs. Neglect the contribution of holes to conductivity. **[2]**

19. The ground state energy of hydrogen atom is -13.6 eV . What are the kinetic and potential energies of the electron in this state? **[2]**

20. A bar magnet 30 cm long is placed in the magnetic meridian with its north pole pointing geographical south. The neutral point is found at a distance of 30 cm from its centre. Calculate the pole strength of the magnet. Given B_H = 0.34 G. **[2]**

OR

A short bar magnet has a magnetic moment of 0.48 JT^{-1}. Give the direction and magnitude of the magnetic field produced by the magnet at a distance of 10 cm from the centre of the magnet on

a. the axis,

b. the equatorial lines (normal bisector) of the magnet.

21. How is the equation for Ampere's circuital law modified in the presence of displacement current? Explain. **[2]**

OR

Which one has the lowest and which one has the highest resistance : ammeter, a voltmeter or a galvanometer?

Section C

22. Answer the following questions: **[3]**

i. What is the order of magnitude of the resistance of a (dry) human body?

ii. If the resistance of our body is so large, why does one experience a strong shock (sometimes even fatal) when one accidentally touches the live wire of, say 240 V supply?

iii. There is an impression among many people that a person touching a high power line gets **stuck** with the line. Is that true? Explain.

iv. Currents of the order of 0.1 A through the human body are fatal. What causes the death: heating of the body due to electric current or something else?

v. A nerve fiber contains an m em brane separating two conducting **fluids** maintained at a potential difference. What is the order of this potential difference?

23. The maximum kinetic energy of the photoelectrons emitted is doubled when the wavelength of light incident on the photosensitive surface changes from λ_1 to λ_2. Deduce expressions for the threshold wavelength and work function for the metal surface in terms of λ_1 and λ_2. **[3]**

24. a. Explain the formation of a p-n junction. **[3]**

b. Can we take one slab of p-type semiconductor and physically join it to another n-type semiconductor to get a p-n junction? Explain.

25. i. Draw a plot showing the variation of potential energy of a pair of nucleons as a function of their separation. Mark the regions where the nuclear force is **[3]**

a. attractive and

b. repulsive.

ii. In the nuclear reaction ${}_0n^1 + {}^{235}_{92}U \rightarrow {}^{a}_{54}Xe + {}^{94}_{b}Sr + 2{}_0n^1$ determine the values of a and b.

26. The photon emitted during the de-excitation from the first excited level to the ground state of hydrogen atom is used to irradiate a photocathode of a photocell, in which stopping potential of 5 V is used. Calculate the work function of the cathode used. **[3]**

27. Derive the expression for the magnetic energy stored in a solenoid in terms of magnetic field B, area A and length l of the solenoid carrying a steady current I. How does this magnetic energy per unit volume compare with the electrostatic energy density stored in a parallel plate capacitor? **[3]**

OR

a. A toroidal solenoid with an air core has an average radius of 0.15 m, area of cross section $12 \times 10^{-4} m^2$ and 1200 turns. Obtain the self inductance of the toroid. Ignore field variation across the cross section of the toroid.

b. A second coil of 300 turns is wound closely on the toroid above. If the current in the primary coil is increased from zero to 2.0 A in 0.05 s, obtain the induced emf in the secondary coil.

28. a. When monochromatic light is incident on a surface separating two media, the reflected and refracted light both have the same frequency as the incident frequency. Explain why? **[3]**

b. When light travels from a rarer to a denser medium, the speed decreases. Does the reduction in speed imply a reduction in the energy carried by the light wave?

c. In the wave picture of light, intensity of light is determined by the square of the amplitude of the wave. What determines the intensity of light in the photon picture of light.

Section D

29. **Read the text carefully and answer the questions:** **[4]**

Maxwell showed that the speed of an electromagnetic wave depends on the permeability and permittivity of the medium through which it travels. The speed of an electromagnetic wave in free space is given by c = $\frac{1}{\sqrt{\mu_0 \varepsilon_0}}$. The fact led Maxwell to predict that light is an electromagnetic wave. The emergence of the speed of light from purely electromagnetic considerations is the crowning achievement of Maxwell's electromagnetic theory. The speed of an electromagnetic wave in any medium of permeability μ and permittivity ε will be $\frac{c}{\sqrt{K\mu_r}}$ where K is the dielectric constant of the medium and μ_r is the relative permeability.

(a) The dimensions of $\frac{1}{2}\varepsilon_0 E^2$ (ε_0 : permittivity of free space; E = electric field) is

a) ML^2T^{-2} b) MLT^{-1}

c) ML^2T^{-1} d) $ML^{-1}T^{-2}$

(b) Let $[\varepsilon_0]$ denote the dimensional formula of the permittivity of the vacuum. If M = mass, L = length, T = time and A = electric current, then

a) $[\varepsilon_0] = MLT^{-2}A^{-2}$ b) $[\varepsilon_0] = ML^2T^{-1}$

c) $[\varepsilon_0] = M^{-1}L^{-3}T^4A^2$ d) $[\varepsilon_0] = M^{-1}L^{-3}T^2A$

(c) An electromagnetic wave of frequency 3 MHz passes from vacuum into a dielectric medium with permittivity $\varepsilon = 4$. Then

a) wavelength is doubled and the frequency becomes half

b) wavelength and frequency both remain unchanged

c) wavelength is doubled and the frequency remains unchanged

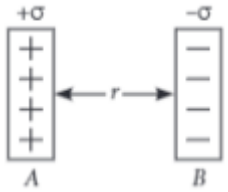
d) wavelength is halved and the frequency remains unchanged.

(d) Which of the following are not electromagnetic waves?
cosmic rays, γ-rays, β-rays, X-rays

a) γ-rays b) β-rays

c) X-rays d) cosmic rays

30. Surface charge density is defined as charge per unit surface area of surface charge distribution. i.e., $\sigma = \frac{dq}{dS}$. Two large, thin metal plates are parallel and close to each other. On their inner faces, the plates have surface charge densities of opposite signs having magnitude of 17.0×10^{-22} Cm^{-2} as shown. The intensity of electric field at a point is $E = \frac{\sigma}{\varepsilon_0}$, where ε_0 = permittivity of free space. **[4]**



i. What is E in the outer region of the first plate? (2)

ii. What is E in the outer region of the second plate? (1)

iii. What is E between the plates? (1)

Section E

31. a. With the help of a labelled ray diagram, explain the construction and working of a Cassegrain reflecting telescope. **[5]**

b. An amateur astronomer wishes to estimate roughly the size of the Sun using his crude telescope consisting of an objective lens of focal length 200 cm and an eyepiece of focal length 10 cm. By adjusting the distance of the eyepiece from the objective, he obtains an image of the Sun on a screen 40 cm behind the eyepiece. The diameter of the Sun's image is measured to be 6.0 cm. Estimate the Sun's size, given that the average Earth-Sun distance is 1.5×10^{11} m.

OR

i. State Huygens principle. A plane wave is incident at an angle i on a reflecting surface. Construct the corresponding reflected wavefront. Using this diagram, prove that the angle of reflection is equal to the angle of incidence.

ii. What are the coherent sources of light? Can two independent sodium lamps act like coherent sources? Explain.

iii. A beam of light consisting of a known wavelength 520 nm and an unknown wavelength λ, used in Young's double slit experiment produces two interference patterns such that the fourth bright fringe of unknown wavelength coincides with the fifth bright fringe of known wavelength. Find the value of λ.

32. i. A. Why does the electric field inside a dielectric slab decrease when kept in an external electric field? **[5]**

B. Derive an expression for the capacitance of a parallel plate capacitor filled with a medium of dielectric constant K.

ii. A charge q = 2 μC is placed at the centre of a sphere of radius 20 cm. What is the amount of work done in moving 4 μC from one point to another point on its surface?

iii. Write a relation for polarisation $\vec{P}$ of a dielectric material in the presence of an external electric field.

OR

Derive an expression for equivalent capacitance of three capacitors when connected

i. in series and

ii. in parallel.

33. A small town with a demand of 800 kW of electric power at 220 V is situated 15 km away from an electric plant generating power at 440 V. The resistance of the two wirelines carrying power is 0.5 Ω per km. The town gets power from the line through a 4000 - 220 V step-down transformer at a sub-station in the town. **[5]**

a. Estimate the line power loss in the form of heat.

b. How much power must the plant supply, assuming there is negligible power loss due to leakage?

c. Characterize the step-up transformer at the plant.

OR

i. With the help of a labelled diagram, describe the principle and working of an ac generator. Hence, obtain an expression for the instantaneous value of the emf generated.

ii. The coil of an ac generator consists of 100 turns of wire, each of area 0.5 m^2. The resistance of the wire is 100 Ω. The coil is rotating in a magnetic field of 0.8 T perpendicular to its axis of rotation, at a constant angular speed of 60 radian per second. Calculate the maximum emf generated and power dissipated in the coil.

Solution

Section A

1.

(d) Ions

Explanation:

When p-n junction is formed, the electrons from n-region diffuse through the junction into p-region provide positive ions in n-region similarly holes from p-region diffuse into n-region provide negative ions in p-region. Due to these ions, an electric field is set up across the junction from positive ions to negative ions. This electric field sets a potential barrier at the junction.

2.

(d) The strip is narrower at P than at Q

Explanation:

The current density (J) is defined as the current (I) per unit area (A) flowing through a conductor. If the current density varies along the strip, it indicates that the cross-sectional area of the strip is also changing. If the strip is narrower at point P than at point Q, it means that for the same amount of current flowing, the current density at P would be higher compared to Q, where the area is larger. This explains the variation in current density shown in the graph. Thus, the statement that the strip is narrower at P than at Q correctly accounts for the observed variation in current density.

3.

(b) $A + \delta_m = 2i$

Explanation:

For refraction through prism,

$i_1 + i_2 = \delta + A$ and $r_1 + r_2 = A$

For minimum deviation,

$i_1 = i_2 = i$ and $r_1 = r_2 = r$

So, $i = \frac{(A+\delta_m)}{2}$

$\therefore A + \delta_m = 2i$

4.

(b) $[L^2A]$

Explanation:

Magnetic moment = Current $\times$ area

$[M] = [L^2A]$

5.

(c) one on which aluminium oxide film is formed

Explanation:

Aluminium electrolytic capacitors have the Aluminium foil anode (positive terminal) which is etched and covered with a layer of Aluminium Oxide which acts as a dielectric. The whole assembly is covered using a paper separator soaked in electrolyte such as, Borax or Glycol and covered by Aluminium foil which acts as cathode (negative electrode)

6. **(c)** low resistance in parallel
Explanation:
A galvanometer can be changed into an ammeter by providing a low resistance in parallel.

7. **(d)** Faraday's law
Explanation:
According to Faraday's laws,
$|\varepsilon| = \frac{d\phi}{dt}$

8. **(a)** Magnetic dipole
Explanation:
Magnetic dipole

9. **(a)** Prism
Explanation:
A prism cannot be used to produce two coherent sources of light.

10. **(b)** $\frac{2\lambda}{4\pi\varepsilon_0 R}$
Explanation:
the field at center is given by $\frac{2\lambda}{4\pi\varepsilon_0 R}$

11. **(b)** 3 corresponds to forward bias of junction and 1 corresponds to reverse bias of junction
Explanation:
When p-n junction is forward biased, it opposes the potential barrier across junction. When p-n junction is reverse biased, it supports the potential barrier junction, resulting increase in potential barrier across the junction.

12. **(d)** fitting eye-piece of high power
Explanation:
Magnification of telescope can be increased by using eyepiece of lower focal length (f_e). Since power is inversely proportional to focal length, eyepiece of large power will increase magnification of the telescope.

13. **(a)** Both A and R are true and R is the correct explanation of A.
Explanation:
Both A and R are true and R is the correct explanation of A.

14. **(a)** Both A and R are true and R is the correct explanation of A.
Explanation:
Inside the charged metallic sphere every point is at the same electric potential, hence, W = q ΔV = 0. But outside the sphere, there exists a potential gradient at every point, hence, W $\neq$ 0.

15. **(c)** A is true but R is false.
Explanation:
For diffraction of a wave, the size of an obstacle or aperture should be comparable to the size of As wavelength of the wave. As the wavelength of light is of the order of 10^{-6} m and obstacle or aperture of the size are rare, therefore, diffraction is not common in light waves. On the

contrary, the wavelength of sound is of the order of 1 m and obstacle/aperture of this size are readily available, therefore, diffraction is common in sound.

16.

(d) A is false and R is also false

Explanation:

Resistance offered by an inductor is a DC circuit at t = 0 is infinity, which decreases to zero at steady state.

Section B

17. a. Microwave

    b. When a charge oscillates with some frequency. It produces an oscillating electric field and magnetic field in space. So, an electromagnetic wave is produced. The frequency of the em wave is equal to the frequency of oscillation of the charge. Hence energy associated with the em wave comes at the expense of the energy of the source. If the em wave of energy U strikes on a surface and gets completely absorbed, total momentum delivery to the surface is p = $\frac{U}{E}$. Hence em wave also carry momentum.

    c. The em wave consists of oscillating electric and magnetic fields, So net energy density of em wave is

    $U = U_E + U_B$

    $U = \frac{1}{2}\varepsilon_0 E^2 + \frac{1}{2}\frac{B^2}{\mu_0}$

18. Here $\sigma = 5\Omega^{-1}\ \text{cm}^{-1}$, μ_e = 3900 $cm^2\ V^{-1}\ s^{-1}$, n_e = ?

    If we neglect the contribution of holes to conductivity, then

    $\sigma = \frac{1}{\rho} = en_e\mu_e$

    $\therefore$ Electron density,

    $n_e = \frac{\sigma}{e\mu_e} = \frac{5}{1.6\times10^{-19}\times3900}\ cm^{-3}$

    $= 8.01 \times 10^{15}\ cm^{-3}$

19. Here, ground state energy, E = -13.6 eV

    Kinetic energy, $E_k = \frac{1}{4\pi\varepsilon_0}\cdot\frac{e^2}{2r}$

    and Potential energy, $E_p = -\frac{1}{4\pi\varepsilon_0}\frac{e^2}{r}\left[\because E_p = -2E_k\right]$

    Total energy, $E = E_k + E_p$

    $= \frac{1}{4\pi\varepsilon_0}\cdot\frac{e^2}{2r} - \frac{1}{4\pi\varepsilon_0}\cdot\frac{e^2}{r}$

    $E = -\frac{1}{2}\left(\frac{1}{4\pi\varepsilon_0}\cdot\frac{e^2}{r}\right)$

    $-13.6 = -\frac{1}{2}\left(\frac{1}{4\pi\varepsilon_0}\cdot\frac{e^2}{r}\right)$

    $\therefore \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r} = 27.2$

    $\therefore E_k = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{2r} = \frac{27.2}{2}eV = 13.6eV$

    $E_p = -\frac{1}{4\pi\varepsilon_0}\cdot\frac{e^2}{r} = -27.2\ eV$

20. When a magnet is placed in such a way that its north pole points towards the south, the neutral point is obtained at the axis of the magnet and as the point is said to be a neutral point, the magnitude of earth's magnetic field is equal to the magnetic field of the magnet.

    therefore, we have, $B_{magnet} = B_H$

    The magnetic field of the magnet at an axial point is given as

    $B_{magnet} = \frac{\mu_0}{4\pi}\frac{2Md}{\left(d^2-l^2\right)^2}$ where M is the magnetic moment.

Given: d = 30 cm = 0.3 m, 2l = 30 cm $\rightarrow$ l = 0.15 m and B_H = 0.34 G = 0.34 $\times$ 10^{-4} T.

Let us substitute these values and find the magnetic moment.

$M = \left(B_{\text{magnet}}\right)\left(\frac{4\pi}{\mu_0}\right)\left(\frac{\left(d^2-l^2\right)^2}{2d}\right)$

$\Rightarrow M = \left(B_H\right)\left(\frac{4\pi}{\mu_0}\right)\left(\frac{\left(d^2-l^2\right)^2}{2d}\right)$

$\Rightarrow M = (0.34 \times 10^{-4})\left(\frac{1}{10^{-7}}\right)\left(\frac{\left(0.3^2-0.15^2\right)^2}{2\times 0.3}\right)$

$\Rightarrow$ M = 2.582 Am^2

So, pole strength of the magnet will be,

$\therefore m = \frac{M}{2l} = \frac{2.582}{0.3}$ = 8.607 Am

Therefore, the magnetic pole strength of the given magnet is 8.6 Am.

OR

Given M = 0.48 JT^{-1}, r = 10 cm = 0.1 m

a. Magnetic field at its axis,

$B_a = \frac{\mu_0}{4\pi}\frac{2M}{r^3}$

$B_a = \frac{4\pi\times 10^{-7}\times 2\times 0.48}{4\pi\times(0.1)^3}$

$B_a = 960 \times 10^{-7}\ T = 960 \times 10^{-3} G$

B_a = 0.96G along N-S line.

b. Magnetic field along the equatorial line,

$B_e = \frac{\mu_0}{4\pi}\frac{M}{r^3}$

$B_e = \frac{4\pi\times 10^{-7}\times 0.48}{4\pi\times(0.1)^2}$

$B_e = 480 \times 10^{-7} T = 480 \times 10^{-3} G$

B_e = 0.48G along N-S line.

21. $\oint \vec{B}\cdot\overrightarrow{dl} = \mu_0 i$

There is an inconsistency in the Ampere's Circuital law.

Maxwell modified it as

$\oint \vec{B}\cdot\overrightarrow{dl} = \mu_0\left(i_c + i_d\right)$

where $i_d = \varepsilon_0\frac{d\phi_E}{dt}$

OR

Ammeter has the lowest resistance and voltmeter has the highest resistance. Since an ammeter is obtained by connecting a small resistance m parallel with the galvanometer, the effective resistance is smaller than that of the galvanometer. The voltmeter is obtained by connecting a high resistance in series with the galvanometer, so its resistance is higher than that of the galvanometer.

Section C

22. i. About 10 kΩ, it is mainly due to skin through which current enters and leaves our body.

ii. It is because our body is sensitive to minute currents even as low as a few mA.

iii. This impression is misleading. There is no special attractive force that keeps a person 'stuck' with a high power line. Actually, current of the order of 0.05 A or even much less is enough to disorganise our nervous system. The result is that the affected person may temporarily lose his ability to exercise his nervous control to get himself 'free' from the high voltage point.

iv. The cause of death is not heating, though a person may receive bums if the currents are too large. The cause of death is the interference caused by external currents in our highly sensitive nervous system which is basically electrical in nature. External currents cause

convulsive actions and especially interfere with the nerve processes related to our heart beating. Beyond a certain point, this interference is fatal.

v. About 0.1 V.

23. Given that

Initial kinetic energy of photoelectrons is given by = K_1

Final kinetic energy of photoelectrons is given by $K_2 = 2K_1$

Wavelength of light changes from λ_1 to λ_2

Let the threshold frequency is ν_0 and work function is ϕ_0

Now, we know that:-

$\frac{hc}{\lambda} = \phi_0 + KE$

$\frac{hc}{\lambda_1} = \phi_0 + K_1$ ...(i)

$\frac{hc}{\lambda_2} = \phi_0 + K_2$ ...(ii)

$K_2 = 2K_1$

$\frac{hc}{\lambda_2} = \phi_0 + 2K_1$ ...(iii)

$\frac{2hc}{\lambda_1} = 2\phi_0 + 2K_1$ (eq (i) $\times$ 2)

$\frac{2hc}{\lambda_1} - \frac{hc}{\lambda_2} = \phi_0$

$\Rightarrow \phi_0 = hc\left(\frac{2\lambda_2 - \lambda_1}{\lambda_1\lambda_2}\right)$

We know

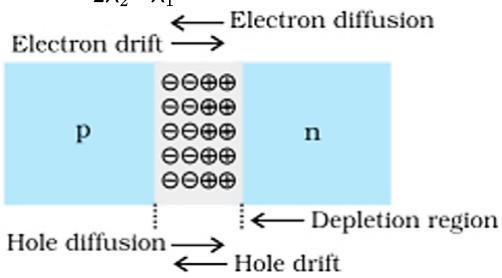
work function is given by $\phi_0 = \frac{hc}{\lambda_0}$

$\frac{hc}{\lambda_0} = hc\left(\frac{2\lambda_2 - \lambda_1}{\lambda_1\lambda_2}\right)$

$\frac{1}{\lambda_0} = \frac{2\lambda_2 - \lambda_1}{\lambda_1\lambda_2}$

$\lambda_0 = \frac{\lambda_1\lambda_2}{2\lambda_2 - \lambda_1}$

24.



During the formation of p-n junction due to concentration gradient across p and n sides, holes diffuse from p side to n side and electrons diffuse from n side to p side This motion of charge carriers gives rise to diffusion current across the junction.

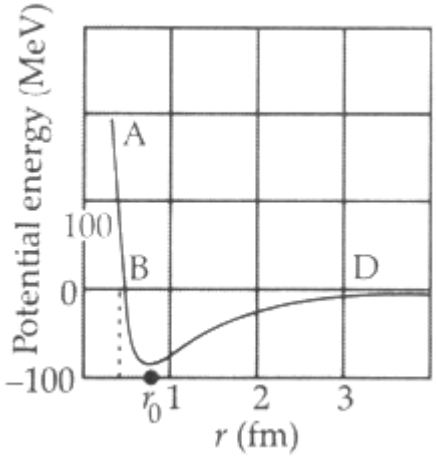
Diffusion of electrons develops a layer of positive charge on n side of the junction and diffusion of holes develops a layer of negative charge on p side of the junction.

Due to this space charge region on either side of the junction an electric field is developed. This electric field drifts charge carriers across the junction and sets up drift current in a direction opposite to diffusion current.

This process continues until the diffusion current is equal to drift current. Thus p-n junction is formed.

No, Any slab, howsoever flat, will have roughness much larger than the inter-atomic spacing ($\sim$2 to 3 $\mathring{A}$) and hence continuous contact at the atomic level will not be possible. The junction will behave as a discontinuity for the flowing charge carriers.

25. i.



For r > r_0, the force is attractive

For r < r_0, the force is repulsive

ii. We have, In nuclear reactions , mass no .is conserved Hence ,

1 + 235 =a + 94 + 2 × 1

∴ a = 2 3 6 - 9 6 = 140

In nuclear reactions , charge no. is conserved .so 0 + 92 = 54 + b + 2 × 0

∴ b = 92 - 54 = 38

26. Energy of incident photon = E_2 - E_1 = -3.4 - (13.6) = 10.2 eV

K.E. of photo electron = eV_0=5 eV

By conservation of energy,

Energy of incident photon = K.E. of photo electron + Work function

10.2 eV = 5 eV + W_0

∴ W_0 = 5.2 eV

27. Rate of work done,

$\frac{dW}{dt} = |\varepsilon| i$

dW = $\left(LI\frac{dI}{dt}\right) dt$

dW = LI dl

Total amount of work done,

$\int dW = \int LIdI$

W = $\frac{1}{2}LI^2$

For the solenoid:

Inductance, L = $\mu_0 n^2 AE$; B = $\mu_0 nI$

∴ W = U_B = $\frac{1}{2}LI^2$

= $\frac{1}{2}\left(\mu_0 n^2 Al\right)\left(\frac{B}{\mu_0 n}\right)^2$

= $\frac{B^2 Al}{2\mu_0}$

Magnetic energy per unit volume

Electrostatic Energy Stored Per Unit Volume stored in parallel plate capacitor = $\frac{1}{2}\varepsilon_0 E^2$

OR

a. $B = \mu_0 n_1 I = \frac{\mu_0 N_1 I}{l} = \frac{\mu_0 N_1 I}{2\pi r}$

Total magnetic flux, $\phi_B = N_1 BA = \frac{\mu_0 N_1^2 IA}{2\pi r}$

But $\phi_B = LI$

$\therefore L = \frac{\mu_0 N_1^2 A}{2\pi r}$

Or $L = \frac{4\pi \times 10^{-7} \times 1200 \times 1200 \times 12 \times 10^{-4}}{2\pi \times 0.15}$

$= 2.3 \times 10^{-3} H$ = 2.3 mH

b. $|E| = \frac{d}{dt}(\phi_2)$ where ϕ_2 is the total magnetic flux linked with the second coil.

$|E| = \frac{d}{dt}(N_2 BA) = \frac{d}{dt}\left[N_2 \frac{\mu_0 N_1 I}{2\pi r} A\right]$

$|E| = \frac{\mu_0 N_1 N_2 A}{2\pi r} \frac{dI}{dt}$

$|E| = \frac{4\pi \times 10^{-7} \times 1200 \times 300 \times 12 \times 10^{-4} \times 2}{2\pi \times 0.15 \times 0.05}$ = 0.023 V

28. a. Reflection and refraction arise through interaction of incident light with the atomic constituents of matter. Atoms may be viewed as oscillators, which take up the frequency of the external agency (light) causing forced oscillations. The frequency of light emitted by a charged oscillator equals its frequency of oscillation. Thus, the frequency of scattered light equals the frequency of incident light.

b. No, Energy carried by a wave depends on the amplitude of the wave, not on the speed of wave propagation.

c. For a given frequency, intensity of light in the photon picture is determined by the number of photons crossing an unit area per unit time.

Section D

29. **Read the text carefully and answer the questions:**

Maxwell showed that the speed of an electromagnetic wave depends on the permeability and permittivity of the medium through which it travels. The speed of an electromagnetic wave in free space is given by c = $\frac{1}{\sqrt{\mu_0 \varepsilon_0}}$. The fact led Maxwell to predict that light is an electromagnetic wave. The emergence of the speed of light from purely electromagnetic considerations is the crowning achievement of Maxwell's electromagnetic theory. The speed of an electromagnetic wave in any medium of permeability μ and permittivity ε will be $\frac{c}{\sqrt{K\mu_r}}$ where K is the dielectric constant of the medium and μ_r is the relative permeability.

(a) **(d)** $ML^{-1}T^{-2}$

Explanation:

$\frac{1}{2}\varepsilon_0 E^2$ = energy density = $\frac{\text{Energy}}{\text{Volume}}$

$\therefore \left[\frac{1}{2}\varepsilon_0 E^2\right] = \frac{ML^2 T^{-2}}{L^3}$ = $[ML^{-1}T^{-2}]$

(b) **(c)** $[\varepsilon_0] = M^{-1}L^{-3}T^4A^2$

Explanation:

As $\varepsilon_0 = \frac{q_1 q_2}{4\pi F R^2}$ (from Coulomb's law)

$\varepsilon_0 = \frac{C^2}{Nm^2} \frac{[AT]^2}{MLT^{-2} L^2} = M^{-1}L^{-3}T^4A^2$

(c) **(d)** wavelength is halved and the frequency remains unchanged.

Explanation:

The frequency of the electromagnetic wave remains same when it passes from one medium to another.

Refractive index of the medium, n = $\sqrt{\frac{\varepsilon}{\varepsilon_0}} = \sqrt{\frac{4}{1}} = 2$

Wavelength of the electromagnetic wave in the medium,

$\lambda_{med} = \frac{\lambda}{n} = \frac{\lambda}{2}$

(d) **(b)** β-rays

Explanation:

β-rays consists of electrons which are not electromagnetic in nature.

30. i. There are two plates A and B having surface charge densities, $\sigma_A = 17.0 \times 10^{-22}$ C/m^2 on B, respectively. According to Gauss' theorem, if the plates have same surface charge density but having opposite signs, then the electric field in region I is zero.

$E_I = E_A + E_B = \frac{\sigma}{2\varepsilon_0} + \left(-\frac{\sigma}{2\varepsilon_0}\right) = 0$

ii. The electric field in region III is also zero.

$E_{III} = E_A + E_B = \frac{\sigma}{2\varepsilon_0} + \left(-\frac{\sigma}{2\varepsilon_0}\right) = 0$

iii. In region II or between the plates, the electric field.

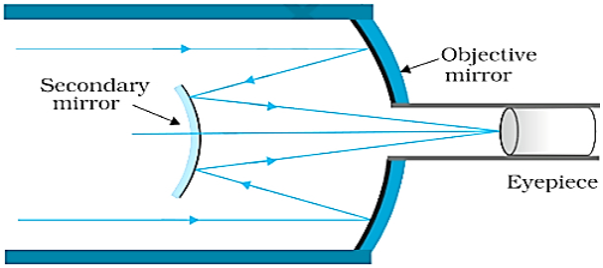
$E_{II} = E_A - E_B = \frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0}$

$= \frac{\sigma(\sigma_A \text{ or } \sigma_B)}{\varepsilon_0} = \frac{17.0\times10^{-22}}{8.85\times10^{-12}}$

$E = 1.9 \times 10^{-10}$ NC^{-1}

Section E

31. a.



It consists for large concave (primary) paraboidal mirror having in its central part a hole. There is a small convex (secondary) mirror near the focus of concave mirror. Eye pieces if placed near the hole of the concave mirror.

The parallel rays from distance object are reflected by the large concave mirror. These rays fall on the convex mirror which reflects these rays outside the hole. The final magnified image in formed.

b. For eyepiece.

$\frac{1}{v_e} - \frac{1}{u_e} = \frac{1}{f_e}$

or $\frac{1}{u_e} = \frac{1}{v_e} - \frac{1}{f_e} = \frac{1}{40} - \frac{1}{10}$

$u_e = \frac{40}{3}$ cm

Magnification produced by eye pieces is

$m_e = \frac{v_e}{|u_e|} = \frac{40}{\frac{40}{3}} = 3$

Diameter of the image formed by the objective is

$d = \frac{6}{3} = 2$ cm

If D be the diameter of the SUN then the angle subtended by it on the objective will be

$\alpha = \frac{D}{1.5\times10^{11}}$ rad

Angle subtended by the image at the objective

= angle subtended by the SUN

$\therefore \alpha = \frac{\text{size of image}}{f_o} = \frac{2}{200} = \frac{1}{100}$ rad.

$\therefore \frac{D}{1.5\times10^{11}} = \frac{1}{100}$

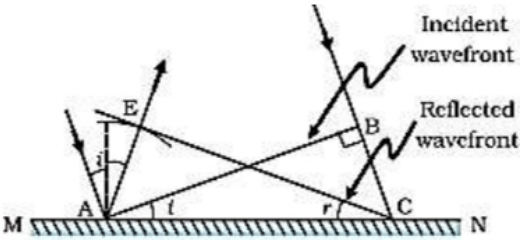
or

$D = 1.5 \times 10^9$ m

OR

i. Each point of the wavefront is the source of a secondary disturbance and the wavelets emanating from these points spread out in all directions with the spread of the wave. Each

point of the wavefront is the source of a secondary disturbance and the wavelets emanating from these points spread out in all directions with the speed of the wave. These wavelets emanating from the wavefront are usually referred to as secondary wavelets and if we draw a common tangent to all these spheres, we obtain the new position of the wavefront at a later time.



△EAC is congruent to △BAC; so <i = <r

ii. Two sources are said to be coherent if the phase difference between them does not change with time.

No, two independent sodium lamps cannot be coherent.

Two independent sodium lamps cannot be coherent as the phase between them does not remain constant with time.

iii. $4\beta_2 = 5\beta_1$

$4 \times \frac{\lambda D}{d} = 5 \times \frac{\lambda_{\text{known}}\, D}{d}$

$\Rightarrow \lambda = \frac{5}{4} \times \lambda_{\text{hnoun}}$

$= \frac{5}{4} \times 520$

= 650 nm

32. i. A. A dielectric material gets polarized when it is placed in an external electric field. The field produced due to the polarization of material reduces the effect of external electric field. Hence, the electric field inside a dielectric decreases.

B. Electric field in vacuum between the plates = E0 = $\frac{\sigma}{\varepsilon_o}$

Electric field in dielectric between the plates, E = $\frac{E_0}{K}$

Potential difference between the capacitor plates

$V = Et + E_0(d - t)$

where 't' is the thickness of dielectric slab.

$V = \frac{E_0}{K} t + E_0(\, d - t)$

$V = \frac{\sigma}{\varepsilon_o}\left[\frac{t}{K} + (d - t)\right]$

$V = \frac{\sigma}{\varepsilon_o}\left[\frac{t + K(d-t)}{K}\right]$

As $C = \frac{Q}{V}$

$\Rightarrow C = \frac{\varepsilon_0 AK}{t + K(d-t)}$

ii. The surface of the sphere is equipotential. So, the work done in moving the charge from one point to the other is zero.

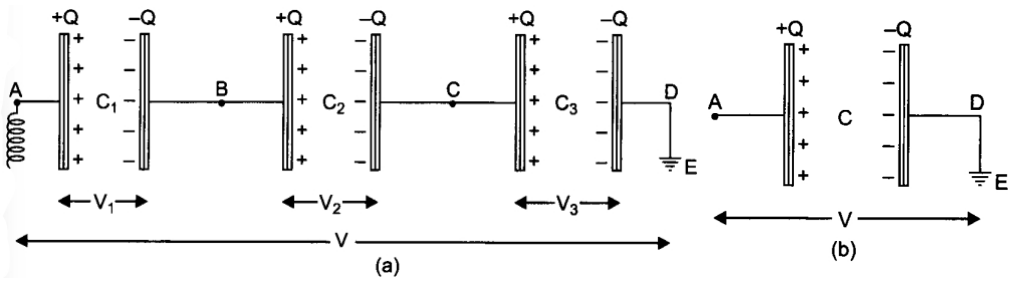
$W = q\,\Delta V$ ($\because \Delta V = 0$)

= 0

iii. $P = \chi E$

OR

i. In fig. (a) three capacitors of capacitances C_1, C_2, C_3 are connected in series between points A and D.



In series first plate of each capacitor has charge +Q and second plate of each capacitor has charge -Q i.e., charge on each capacitor is Q.

Let the potential differences across the capacitors C_1, C_2, C_3 be V_1, V_2, V_3 respectively. As the second plate of first capacitor C_1 and first plate of second capacitor C_2 are connected together, their potentials are equal. Let this common potential be V_B. Similarly the common potential of second plate of C_2 and first plate of C_3 is V_C. The second plate of capacitor C_3 is connected to earth, therefore its potential $V_D = 0$. As charge flows from higher potential to lower potential, therefore $V_A > V_B > V_C > V_D$.

For the first capacitor, $V_1 = V_A - V_B = \frac{Q}{C_1}$ ...(i)

For the second capacitor, $V_2 = V_B - V_C = \frac{Q}{C_2}$ ...(ii)

For the third capacitor, $V_3 = V_C - V_D = \frac{Q}{C_3}$ ...(iii)

Adding (i), (ii) and (iii), we get

$V_1 + V_2 + V_3 = V_A - V_D = Q\left[\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right]$ ...(iv)

If V be the potential difference between A and D, then

$V_A - V_D = V$

$\therefore$ From (iv), we get

$V = (V_1 + V_2 + V_3) = Q\left[\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right]$ ...(v)

If in place of all the three capacitors, only one capacitor is placed between A and D such that on giving it charge Q, the potential difference between its plates become V, then it will be called **equivalent capacitor**. If its capacitance is C, then

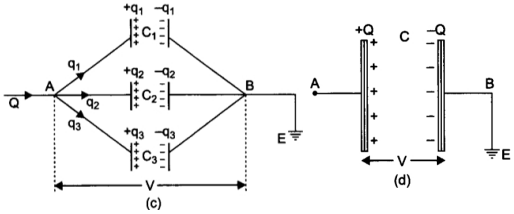
$V = \frac{Q}{C}$ ...(vi)

Comparing (v) and (vi), we get

$\frac{Q}{C} = Q\left[\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right]$ or $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$ ...(vii)

Thus in series arrangement, "The reciprocal of equivalent capacitance is equal to the sum of the reciprocals of the individual capacitors."

ii. **Parallel Arrangement:** In fig. (c) three capacitors of capacitance C_1, C_2, C_3 are connected in parallel.



In parallel the potential difference across each capacitor is same V (say). Clearly the potential difference between plates of each capacitor

$V_A - V_B = V$ (say)

The charge Q given to capacitors is divided on capacitors C_1, C_2, C_3.

Let q_1, q_2, q_3 be the charges on capacitors C_1, C_2, C_3 respectively.

Then $Q = q_1 + q_2 + q_3$ ...(I)

and $q_1 = C_1V, q_2 = C_2V, q_3 = C_3V$

Substituting these values in (i), we get

$Q = C_1V + C_2V + C_3V$ or $Q = (C_1 + C_2 + C_3)V$ ...(ii)

If, in place of all the three capacitors, only one capacitor of capacitance C be connected between A and B; such that on giving it charge Q the potential difference between its plates be V, then it will be called equivalent capacitor. If C be the capacitance of equivalent capacitor, then

$Q = CV$ ...(iii)

Comparing equations (ii) and (iii), we get

$CV = (C_1 + C_2 + C_3)V$ or $C = (C_1 + C_2 + C_3)$

Important Note: It may be noted carefully that the formula for the total capacitance in series and parallel combination of capacitors is the reverse of corresponding formula for combination of resistors in current electricity.

33. Total electric power required,

Supply voltage, V = 220 V

The voltage at which electric plant is generating power, V' = 440 V

Distance between the town and power generating station, d = 15 km

The resistance of the two-wire lines carrying power = 0.5 Ω/km

Total resistance of the wires, R = (15 + 15) 0.5 = 15 Ω

A step-down transformer of rating 4000 - 220 V is used in the sub-station.

Input voltage is , V_1 = 4000 V

Output voltage is, V_2 = 220 V

Rms current in the wire lines is given as:

$I = \frac{P}{V_1}$

$= \frac{800 \times 10^3}{4000}$ = 200 A

a. Line power loss in the form of heat is given by = I^2R

$= (200)^2 \times 15$

$= 600 \times 10^3$ W

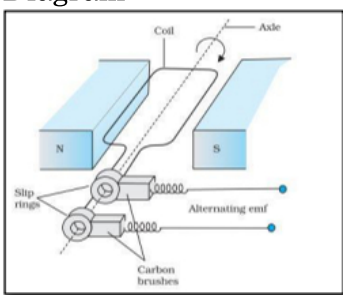
= 600 KW

b. Assuming that the power loss is negligible due to the leakage of the current:
hence Total power supplied by the plant = 800 KW + 600 KW
= 1400 KW

c. Voltage drop in the power line is given by = IR = 200 × 15 = 3000 V
Hence, total voltage transmitted by the plant = 3000 + 4000
= 7000 V
Hence, the rating of the step-up transformer situated at the power plant is 440 V - 7000 V.

OR

i. Diagram



Principle - It is based on the principle of electromagnetic induction. Whenever there is a change in magnetic flux linked with a coil , an emf is induced in the coil.

Working - When a rectangular coil is rotated in a magnetic field, the magnetic flux changes continuously which induces an emf and the direction of current changes periodically.

$\varepsilon = \frac{-Nd\phi}{dt}$

$= -NBA\frac{d}{dt}(\cos\omega t)$

$\varepsilon = NBA\omega\sin\omega t$

ii. $\varepsilon = NBA\omega$

= 100 × 0.8 × 0.5 × 60

= 2400 V

hence, the maximum emf generated will be 2400 V.

Power dissipated, P = $\frac{\varepsilon_{rms}^2}{R}$

$= \frac{\left(\frac{2400}{\sqrt{2}}\right)^2}{100}$

= 28.8 kW