SAMPLE PAPER-01
PHYSICS (Theory)
Class – XII

Time allowed: 3 hours Maximum Marks: 70

Solutions

1. The potential in all points inside the cage is same as cage itself. Potential difference between man and cage is zero. So man does not receive shock.
2. Iron, cobalt and nickel.
3. When fastly moving electron are stopped on a metal target on higher atomic number, then X-rays are produced. The X-rays will also be produced when an electron jumps from higher orbits to a vacancy on the inner complete orbits in an atom of the element.
4. When the light travels from denser medium to rarer medium the critical angle is given by

$$\sin C = \frac{\mu_{rarer}}{\mu_{denser}} \Rightarrow {}_a\mu_r < 1$$

5. In principle, a communication system consists of the following basic units:
   a. Transmitter
   b. Communication channel
   c. Receiver
6. No work is done in moving a charge from one point on equipotential surface to the other. Therefore component of electric field intensity along the equipotential surface is zero. Hence, the surface is perpendicular to field lines.
7. Given N = 50, r = 20 cm = 0.2 m
   I = 12 A
   M = NIA $= NI\left(\pi r^2\right)$

$$M = 50 \text{ x } 12\pi(0.2)^2 = 75.4 Am^2$$

8.

$$\lambda = \frac{c}{v} = \frac{3 \text{ x } 18^8}{5 \text{ x } 10^{19}} = 6 \text{ x } 10^{-12} m$$

$$\lambda = 0.06 \overset{0}{\text{A}}$$

This wavelength corresponds to X-rays which are used in diagnostic tool and treatment for certain forms of cancer.

9.

$$v = \frac{nh}{mr}$$

$$r = \frac{4\pi\varepsilon_0 h^2}{Ze^2 m} n^2$$

$$v = \frac{Ze^2}{4\pi\varepsilon_0 nh}$$

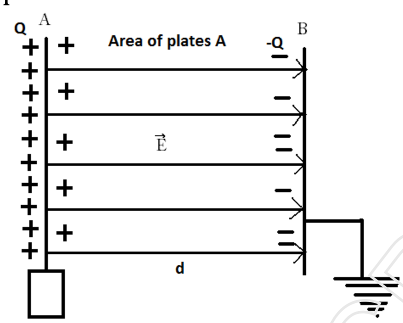
For n =3, Z = 2, v = 1.46 x 10^6 m s^{-1}

$\frac{v}{c} = 0.005$ Non-relativistic approximation is valid because $\frac{v}{c} << 1$.

10. This is because the current gain of common emitter transistor amplifier is much higher as compared with that of common base transistor amplifier.

11. A capacitor is an arrangement of two conductors separated by a dielectric medium. It is used to store the electrical energy in small amount.

Expression for the capacitance of a parallel plate capacitor:
Let us consider the two plates of area of crossection A are separated by a distance d. The space between the plates is filled by an insulating material like, air, mica, glass, etc. One of the plates is insulated and the other plate is earthed as shown in the diagram.



When charge +Q is given to the insulated plate, then a charge –Q is induced on the nearere face of the other plate and +Q is induced on the farther face of the other plate. As this plate is earthed, the charge +Q being free and flows to the earth.
The surface charge density of the insulating plate, σ = Q /A and teh other plate has the surface charge density of - σ.
The electric fields outside the plates is zero.

Electric field between the plates, E = $\frac{\sigma}{\epsilon_0} = \frac{1}{\epsilon_0}\frac{Q}{A}$

Let V be the potential difference between the plates, so V = E × d = $\frac{1}{\epsilon_0}\frac{Q}{A}d$

Capacitance between the plates, C = $\frac{Q}{V} = \frac{Q}{\frac{Qd}{\epsilon_0 A}} = \frac{\epsilon_0 A}{d}$

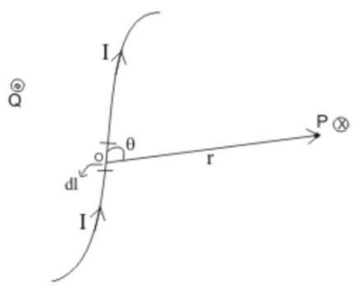
C = $\frac{\epsilon_0 A}{d}$

If the medium is filled with a dielectric of relative permitivity $\in_r$, then the capacitance, C = $\frac{\in_0 \in_r A}{d}$.

12. The materials whose electrical resistance is zero at a certain temperature are called superconductors. For example, mercury becomes superconductor at 4.2 K temperature.

Applications of superconductors:
(i) They are used to make very strong electromagnets.
(ii) They are used to produce very high speed computers.
(iii) they are used for the transmission of electric power.

13. Let us consider a small element AB of length dl carrying current I. Let $\vec{r}$ be the position vector of the point P from the current element $Id\vec{l}$ and θ be the angle between $d\vec{l}$ and $\vec{r}$.



According to the Biot Savart's law, the magnitude of the magnetic field induction dB at a point P due to the current element depends upon the factors :
(i) dB ∝ I
(ii) dB ∝ dl
(iii) dB ∝ Sin θ
(iv) dB ∝ $\frac{1}{r^2}$
By combining all these factors, we get
dB ∝ $\frac{I\,dl\,Sin\,\theta}{r^2}$
dB = $K\frac{I\,dl\,Sin\,\theta}{r^2}$

Where, K is the constant of proportionality and the value of K is $\frac{\mu_0}{4\pi}$. The value of K in S.I. system is 10^{-7} Tm/A and in C.G.S. system the value is 1.
So, dB = $\frac{\mu_0}{4\pi}\frac{I\,dl\,Sin\,\theta}{r^2}$ (in S.I. system)
And dB = $\frac{I\,dl\,Sin\,\theta}{r^2}$ (in C.G.S. system)
In vector form, we can write as
$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I\left(d\vec{l}\times\vec{r}\right)}{r^3}$$

Features of Biot Savart's law:

(i) It is valid for symmetrical current distribution.

(ii) It is applicable to very small length conductor carrying current.

(iii) It cannot be easily verified experimentally.

(iv) The direction of magnetic field vector is perpendicular too current element and distance vector both.

14. The scattering of light is basically change in the direction of light. Lord Rayleigh was the first to deal with scattering of light from air moleecules.

According to the Rayleigh's law of scattering, the amount of light scattered is inversely proportional to the square of the wavelength of the light.

Amount of scattering of light $\propto \dfrac{1}{(wavelength)^2}$

The colour of sky is blue due to the scattering of sunlight. The light coming from the sun, while travelling from through the earth's atmosphere, gets scattered by the number of molecules in the earth's atmosphere. As blue colour has shorter wavelength than red, therefore, blue colour is scattered much more strongly. Thus, the sky appears to be blue.

15. (a) An electron microscope is based on de Broglie hypothesis, according to which a beam of electron behaves as a wave which can be converged or diverged by magnetic or electric field lenses like a beam of light using optical lenses.

(b) For electron: let λ be the de Broglie wavelength of an electron.
Kinetic energy of electron, $E_1 = \frac{1}{2} mv^2$
Or, $mv^2 = 2E_1$
$mv = \sqrt{2E_1 m}$

As we know that, $\lambda = \dfrac{h}{mv}$

$$\lambda = \frac{h}{\sqrt{2E_1 m}}$$

For photon of wavelength λ, Energy, $E_2 = \dfrac{hc}{\lambda}$

$$\frac{E_2}{E_1} = \frac{hc}{\lambda} \times \frac{2\lambda^2 m}{h^2} = \frac{2c\lambda m}{h} = \frac{2\times3\times10^8\times10^{-10}\times9\times10^{-31}}{6.6\times10^{-34}} = \frac{90}{1.1} > 1$$

So, $E_2 > E_1$
Thus, the kinetic energy of photon is greater than that of electron.

16. (a) A good moderator has two properties. It slows down neutrons by elastic collision and it does not remove them from the core by absorbing them. That is why lighter elements are better moderators.

(b) Heavy water is used in reactors using natural uranium a fuel. This is because it has lesser absorption probability of neutrons than ordinary water.

(c) Cadmium rods have a high cross section for neutrons absorption. They are used for controlling the nuclear chain reaction responsible for producing nuclear energy.

17. It is a process of deliberating addition of a desirable impurity atoms to a pure semiconductor to modify its properties in a controlled manner.

Methods of dopping: (i) add the impurity atoms in the melt of the semiconductor, (ii) heat the crystalline semiconductor in an atmosphere containing dopant atoms or molecules so that the latter diffuse into semiconductor and (iii) implant dopant atoms by bombarding the semiconductor with their ions.

18. ΔI_e = 7.89 mA, ΔI_c = 7.8 mA, ΔI_b = ?

$\alpha_{a.c} = \Delta I_c/\Delta I_e = 7.8 / 7.89 = 0.9886$

$\beta_{a.c} = \alpha / (1 - \alpha) = 0.9886 / (1 - 0.9886) = 86.72$

$\beta_{a.c} = \Delta I_c/\Delta I_b$

$\Delta I_b = \Delta I_c/\beta_{a.c} = 7.8 / 86.72 = 89.94 \times 10^{-3}$ mA

19. It is defined as the value of steady current, which would generate the same amount of heat in a given time, as is done by the ac when passed through the same resistance for the same time. The r.m.s value is also called effective value of ac or virtual value of ac. It is represented by I_{rms} or I_{eff} or I_v.

Let the alternating current is represented by

$I = I_0 \sin \omega t$ ...(1)

Let this current flow through a resistance R. In a small time dt, the amount of heat produced in resistance R is

$dH = I^2 R dt$ ...(2)

In one complete cycle, the total amount of heat produced in the resistance R would be

$$H = \int_0^T I^2 R dt$$

$$H = \int_0^T \left(I_0^2 Sin^2 \omega t\right) R dt$$

$$H = I_0^2 R \int_0^T \left(\frac{1 - Cos 2\omega t}{2}\right) dt = \frac{I_0^2 R}{2}\left[\int_0^T 1 dt - \int_0^T Cos 2\omega t \, dt\right]$$

$$H = \frac{I_0^2 R}{2}\left[t - \frac{Sin 2\omega t}{2\omega}\right]_0^T = \frac{I_0^2 R}{2}\left[T - \frac{Sin 2 \times 2\pi}{2\omega}\right]$$

H = $\frac{I_0^2 RT}{2}$ .....(3)

If r.m.s value or virtual value of ac is represented by I_v, then the amount of heat produced in the same resistance R, in the same time T would be

H = $I_v^2 RT$ ....(4)

From equation (3) and (4), we get

$$I_v^2 RT = \frac{I_0^2 RT}{2}$$

$$I_v = \frac{I_0}{\sqrt{2}} = 0.707 I_0$$

Thus, the rms value or effective value or the virtual value of ac is 0.707 times the peak value of ac, i.e., 70.7% of the peak value of ac.

20. The major sources of energy loss in a transformer

(i) Copper loss: The energy loss in the form of heat in copper coils of a transformer. These are minimized by using thick wires.
(ii) Iron loss: It is the loss in the form of heat in the iron core of the transformer. It is due to the formation of eddy currents in the iron core. It is minimized by taking laminated cores.
(iii) Leakage of magnetic flux due to the space between the coils. It can be reduced by winding the primary and secondary coils one over the other.
(iv) Hysteresis loss: It is the loss of energy due to the repeated magnetization and demagnetization of iron core when ac is fed to it. It can be minimized by using a magnetic material which has low hysteresis loss.
(v) Magnetostriction: It is the loss of energy due to the humming noise of the transformer.

21. When high energy electrons are stopped suddenly on a metal of high atomic number, the X rays are produced. They have very high penetrating power. The uses of X rays are as follows:

(i) It is used for the detection of fractures in bones in human body.
(ii) It is used for detection faults, cracks, flaw and holes in final metal products.
(iii) It is used to cure untraceable skin diseases.
(iv) It is used for the investigation of structure of crystals, arrangement of atoms and molecules in complex substances.

22. Comparing the given expression by the standard relation,

$$B_y = B_0\, Sin\left[\frac{2\pi}{\lambda}x + \frac{2\pi t}{T}\right] = B_0\, Sin\left[\frac{2\pi}{\lambda}x + 2\pi\nu t\right]$$

We have, $B_0 = 3 \times 10^{-7}$ Tesla, $\frac{2\pi}{\lambda} = 1.5$

So, $\lambda = \frac{2\pi}{1.5} = 4.19\,m$

$2\pi\nu = 5 \times 10^8$

Or, $\nu = 5 \times 10^8 / 2\Pi = 7.95 \times 10^7$ Hz.

(b) $E_0 = cB_0 = 3 \times 10^8 \times 3 \times 10^{-7} = 90$ V/m

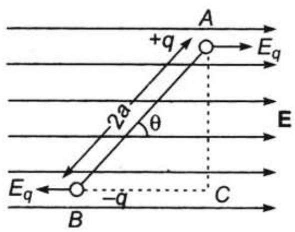
$$E_z = E_0\, Sin\left[\frac{2\pi}{\lambda}x + \frac{2\pi t}{T}\right]$$

$E_z = 90\,Sin\left[1.5x + 5\times10^8 t\right]$ V/m

23. (i) Responsibilities, makes his child to understand the concepts and to generate the interest in the subjects.

(ii) The magnetic field lines in a toroid are concentric circles and the magnetic field lines in a solenoid are straight lines inside the solenoid.

24. **(a):** Let us consider an electric dipole having two equal and opposite charges + q and – q placed at points A and B which are separated by a distance 2a. It is placed in an uniform electric field region of intensity E at an angle θ with the direction of electric field.



Force on charge + q at A = q$\vec{E}$, along the direction of $\vec{E}$

Force on charge - q at B = q$\vec{E}$, along the direction opposite to $\vec{E}$

As the electric field is uniform, so the net force on the dipole is zero. The forces are equal and opposite to each other acting at two different points. So they form a couple which rotates the dipole in anticlock wise direction.

Now, torque on the dipole = either force × perpendicular distance between the two forces

τ = F × AC

= F × AB Sinθ

= F × 2a Sinθ

= qE × 2a Sinθ

= p × E Sinθ

$\vec{\tau} = \vec{p}\times\vec{E}$

The direction of torque is given by the right handed screw rule and is perpendicular to p vector and E vector both.

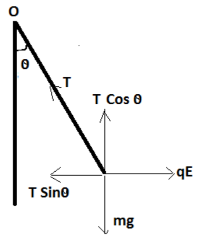
Special cases: (i) If θ = 0°, then τ = 0

(ii) If θ = 90°, then τ = pE

(iii) If θ = 180°, then τ = 0.

(b) Here, m = 80 mg = 80 × 10^{-6} kg, q = 2 × 10^{-8} C, E = 2 × 10^4 V/m

Let T be the tension in the string and θ be the angle it makes with the vertical.



In the equilibrium condition,

T Sinθ = qE ....(1)

T Cosθ = mg ....(2)

On diving equation (1) by equation (2), we get

tan θ = $\frac{qE}{mg} = \frac{(2\times10^{-8}\times2\times10^{-4})}{(80\times10^{-6}\times9.8)} = 0.5102$

tan θ = 27°

Now put the value of θ in equation (1), we get

T = $\frac{qE}{Sin\theta} = \frac{(2\times10^{-8}\times2\times10^{-4})}{Sin27°} = 8.801\times10^{-4}\ N$

25. **(a):** There are two laws of electromagnetic induction.

First law: Whenever the amount of magnetic flux linked with a circuit changes, an emf is induced in the circuit. The induced emf lasts as long as the change in the magnetic flux continues.

Second law: The magnitude of emf induced in a circuit is directly proportional to the rate of change of magnetic flux linked with the circuit.

e = $\frac{-d\phi}{dt}$

Where, dϕ is the change in magnetic flux in time dt. The negative sign shows that the induced emf opposes any change in magnetic flux associated with the circuit.

If there are N turns in the coil, then the induced emf in the coil is

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

(b) v = 960 km / 16 h = 60 km/h = 16.67 m/s

Magnetic field B = 4×10^{-5} T, l = 130 cm = 1.3 m

Induced emf, e = Bvl = $4 \times 10^{-5} \times 16.67 \times 1.3 = 8.6 \times 10^{-4}$ V

Leakage current, i = e / R = $8.6 \times 10^{-4} / 100 = 8.6 \times 10^{-6}$ A

Retarding force, F = B i l = $4 \times 10^{-5} \times 8.6 \times 10^{-6} \times 1.3 = 4.47 \times 10^{-10}$ N.

26. **(a):** Area of each square (object) = 1 mm^2, u = - 9 cm, f = 10 cm

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{10} - \frac{1}{9} = \frac{9-10}{90} = -\frac{1}{90}$$

v = - 90 cm

Magnification, m = $\frac{v}{u} = \frac{90}{9} = 10$

Area of each square in virtual image = $(10)^2 \times 1 = 100$ sq. mm.
(ii) Magnifying power = d / u = 25 / 9 = 2.8
(iii) No, the magnification in (i) cannot be equal to magnifying power in (ii), unless the image is located at least distance of distinct vision.
(b) Here, v = - 25 cm, f = 10 cm, u = ?

$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$

$$\frac{1}{u}=\frac{1}{v}-\frac{1}{f}=-\frac{1}{25}-\frac{1}{10}=\frac{-2-5}{50}=-\frac{7}{50}$$

u = - 7.14 cm

(ii) Magnification, m = $\frac{v}{u}=\frac{25}{7.14}=3.5$

(iii) Magnifying power = d / u = 25 / 7.14 = 3.5
Yes, the magnification and the magnifying power in this case are equal, because image is formed at the least distance of distinct vision.