SAMPLE PAPER-01 (solved)
PHYSICS (Theory)
Class – XII

Time allowed: 3 hours   Maximum Marks: 70

General Instructions:

a) All questions are compulsory.
b) Questions 1 to 5 are one mark questions.
c) Questions 6 to 10 are two marks questions.
d) Questions 11 to 22 are three marks questions.
e) Question 23 is four marks question.
f) Question 24 to 26 are five marks questions.
g) There is no overall choice in the question paper, but internal choice is there.
h) Use of calculator is not permitted.

1. What is the cause of charging?

2. A wire is carrying a current. Is it charged?

3. Why is a neutron most effective as a bullet in nuclear reactions?

4. Define forbidden gap.

5. Name two elementary particles which have almost infinite life time.

6. What do you mean by an ideal dipole and what is the nature of electric field symmetry of the dipole?

7. What is the magnetic moment of an electron orbiting in a circular orbit of radius r with a speed v?

8. Velocity of light in a liquid is 1.5×10^8 m/s and in air it is 3×10^8 m/s. If a ray of light passes from liquid into the air, calculate the value of critical angle.

9. Name a device that converts the change in intensity of illumination into changes in electric current. Give three applications of this device.

10. Define Hertz antenna and Marconi antenna.

11. What do you mean by a capacitor? Derive an expression for the capacitance of a parallel plate capacitor.

12. What do you mean by superconductors? Give three applications of superconductors.

13. State and explain Biot Savart's law. Give its features also.

14. Explain the Rayleigh's law of scattering. Why the colour of sky appears to be blue?

15. (a) What is the principle of electron microscope?
(b) A photon and electron have got same de Broglie wavelength (10^{-10} m), which has greater kinetic energy? Explain.

16. Give reasons for the following:

(a) Lighter elements are better moderators for a nuclear reactor than heavier elements.

(b) In a natural uranium reactor, heavy water is a preferred moderator to ordinary water.

(c) Cadmium rods are provided in a reactor.

17. What do you mean by doping? Give three methods of doping.

18. In a silicon transistor, a change of 7.89 mA in the emitter current produces a voltage of 7.8 mA in the collector current. What voltage in the base current is necessary to produce the equivalent change in the collector current?

19. Define the root mean square value of alternating current and derive its expression.

20. Discuss the energy loses of a transformer.

21. How X rays are produced? Give four uses of X rays.

22. A magnetic field in a plane electromagnetic wave is given by,

$$B_y = 3 \times 10^{-7} \, Sin \left[(1.5 \, rad \, / \, m) \, x + \left(5 \times 10^8 \, rad \, / \, s \right) t \right] tesla \quad .$$

(a) What is the wavelength and frequency of the wave?

(b) Write down the expression for the electric field. (x in metre and t in second).

23. In the birthday party of Vishal, he gave big slinkies as a return gifts to all of his friends. In the next day, in the class of Physics, the teacher explained the concept of production of magnetic fields using current carrying coils and also said that they can make permanent magnets, using such coils by passing high currents through them. Ram, the friend of Vishal asked his father about the coils, and their shape. His father asked him to bring the slinky that his friend gave and expalined the uses of toroid and solenoid.

(i) What values did Ram's father exhibit towards his son?

(ii) What is the difference in the fields produced by the solenoid and toroid?

24. (a) Derive the expression for the torque on an electric dipole placed in a uniform electric field.

(b) A pendulum bob of mass 80 mg carrying a charge of 2×10^{-8} C is at rest in a horizontal uniform electric field of 2×10^4 V/m. Find the tension in the thread of the pendulum and the angle it makes with the vertical.

25. (a) Write the laws of electromagnetic induction.

(b) An express train takes 16 hours to cover the distance of 960 km. The rails are separated by 130 cm and the vertical component of the earth's magnetic field is 4×10^{-5} T. (i) Find the induced emf across the width of the train. (ii) If the leakage resistance between the rails is 100 ohm, find the retarding force on the train due to the magnetic field.

26. (a) A paper is divided into squares each of size 1 mm^2 is being viewed at a distance of 9 cm through a magnifying glass of focal length 10 cm held close to the eye. (i) What is the magnification produced by the lens? How much is the area of each square in the virtual image? (ii) What is the angular magnification of the lens? (iii) Is the magnification in (i) equal to the magnifying power in (ii) Explain.

(b) (i) At what distance should the lens be held in the question above, in order to view the squares distinctly with the maximum possible magnifying power? (ii) What is the magnification in this case? (iii) Is the magnification equal to magnifying power in this case? Explain.

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Solutions

1: The cause of charging is actual transfer of electrons from one body to another.

2: No

3: It is because that a neutron is neutral. It can hit the nucleus directly without being repelled or attracted by the nucleus or electrons.

4: The band separating the valence band and conduction band is called forbidden gap.

5: Electron and proton have almost infinite life time.

6: An electric dipole whose size is very small or negligible is called an ideal dipole. The nature of symmetry of electric field is cylindrical.

7: We know that the orbiting electron behaves as a current loop. The current due to orbital motion of the electron is

$$I = \frac{e}{T} = \frac{e}{2\pi r/v} = \frac{ev}{2\pi r}$$

Area of the current loop (A) = πr^2

Magnetic moment of current loop = IA = $\frac{ev}{2\pi r} \times \pi r^2 = \frac{evr}{2}$

8: v = 1.5 × 10^8 m/s, c = 3 × 10^8 m/s

$$\mu = \frac{c}{v} = \frac{1}{Sin C}$$

$$Sin\ C = \frac{v}{c} = \frac{1.5 \times 10^8}{3 \times 10^8} = 0.5$$

C = Sin^{-1}(0.5) = 30°

9: A photoelectric cell converts changes in intensity illumination into changes in electric current. The applications of photoelectric cell are (i) in burglar alarm, (ii) in fire alarm and (iii) in the reproduction of sound from films in cinema halls.

10: A Hertz antenna is a straight conductor of length equal to half the wavelength of radio signals to be transmitted or received. This antenna is not grounded.

A Marconi antenna is a straight conductor of length equal to quarter of the wavelength of radio signals to be transmitted or received. It held vertically with its lower end touching with the ground.

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 crosssection 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.
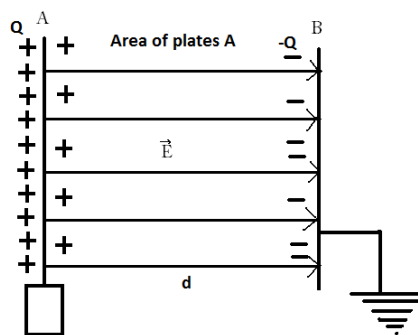
When charge +Q is given to the insulated plate, then a charge –Q is induced on the nearere face of the other plate and +Q is induced on the farther face of the other plate. As this plate is earthed, the charge +Q being free and flows to the earth.

The surface charge density of the insulating plate, $\sigma = Q/A$ and teh other plate has the surface charge density of - σ.

The electric fields outside the plates is zero.

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

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

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

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

If the medium is filled with a dielectric of relative permitivity ϵ_r, then the capacitance, $C = \dfrac{\epsilon_0 \epsilon_r A}{d}$.

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 $I\vec{dl}$ and θ be the angle between $\vec{dl}$ and $\vec{r}$.
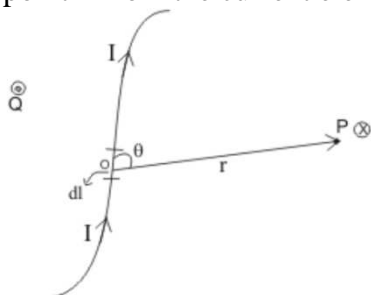
According to the Biot Savart's law, the magnitude of the magnetic field induction dB at a point P due to the current element depends upon the factors :

(i) $dB \propto I$

(ii) $dB \propto dl$

(iii) $dB \propto \sin\theta$

(iv) $dB \propto \dfrac{1}{r^2}$

By combining all these factors, we get

$dB \propto \dfrac{I\, dl\, \sin\theta}{r^2}$

$dB = K\dfrac{I\, dl\, \sin\theta}{r^2}$

Where, K is the constant of proportionality and the value of K is $\dfrac{\mu_0}{4\pi}$. The value of K in S.I. system is 10^{-7} Tm/A and in C.G.S. system the value is 1.

So, $dB = \dfrac{\mu_0}{4\pi}\dfrac{I\, dl\, \sin\theta}{r^2}$ (in S.I. system)

And $dB = \dfrac{I\, dl\, \sin\theta}{r^2}$ (in C.G.S. system)

In vector form, we can write as

$$d\vec{B} = \dfrac{\mu_0}{4\pi}\dfrac{I\left(\vec{dl}\times\vec{r}\right)}{r^3}$$

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, $\lambda = \dfrac{h}{mv}$

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

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

$$\frac{E_2}{E_1} = \frac{hc}{\lambda} \times \frac{2\lambda^2 m}{h^2} = \frac{2c\lambda m}{h} = \frac{2 \times 3 \times 10^8 \times 10^{-10} \times 9 \times 10^{-31}}{6.6 \times 10^{-34}} = \frac{90}{1.1} > 1$$

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: $\Delta I_e = 7.89$ mA, $\Delta I_c = 7.8$ mA, $\Delta I_b = ?$

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

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

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

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

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

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

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

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

$$H = \frac{I_0^2 R T}{2} \quad \text{.....(3)}$$

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

$H = I_v^2 R T$ ….(4)

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

$$I_v^2 R T = \frac{I_0^2 R T}{2}$$

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

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,

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

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

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

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

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

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

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

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

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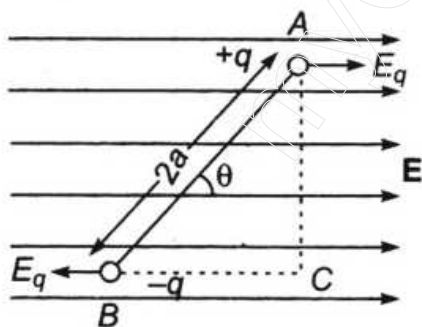
Force on charge + q at A = $q\vec{E}$, along the direction of $\vec{E}$

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

$\tau = F \times AC$

$= F \times AB\ Sin\theta$

$= F \times 2a\ Sin\theta$

$= qE \times 2a\ Sin\theta$

$= p \times E\ Sin\theta$

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

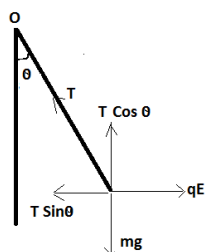The direction of torque is given by the right handed screw rule and is perpendicular to p vector and E vector both.

Special cases: (i) If $\theta = 0°$, then $\tau = 0$

(ii) If $\theta = 90°$, then $\tau = pE$

(iii) If $\theta = 180°$, then $\tau = 0$.

(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 $Sin\theta$ = qE ....(1)

T $Cos\theta$ = mg ....(2)

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

$\tan\theta = \dfrac{qE}{mg} = \dfrac{\left(2\times10^{-8} \times 2\times10^{-4}\right)}{\left(80\times10^{-6} \times 9.8\right)} = 0.5102$

$\tan\theta = 27°$

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

$T = \dfrac{qE}{Sin\theta} = \dfrac{\left(2\times10^{-8} \times 2\times10^{-4}\right)}{Sin27°} = 8. \quad \times10^{-4}\ N$

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, $d\phi$ 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 mm², 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.