SAMPLE PAPER-02 (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 basic use of capacitor?

2. The current i flows in a wire of circular cross section with the free electrons travelling with a drift velocity v. What is the drift velocity of electrons when a current of 2i flows in another wire of twice the radius and of the same material?

3. A radioactive material has a half life of 1 minute. If one of the nuclie decays now, when will the next one decay?

4. What is the value of conductivity of a semiconductor at absolute zero?

5. The surfaces of sunglasses are curved, yet their power may be zero. Why?

6. Define the term electric dipole moment. Is it a scalar or a vector quantity?

7. In what ways electric and magnetic fields are different?

8. Velocity of light in glass is 2×10^8 m/s and that in air 3×10^8 m/s. By how much would an ink dot appear to be raised, when covered by a glass plate 6.0 cm thick?

9. In a photoelectric effect experiment, for radiation with frequency ν_0, with $h\nu_0$ = 8 eV, electrons are emitted with energy 2 eV. What is the energy of the electrons emitted for incoming radiation of frequency $1.25\nu_0$?

10. Why is an FM signal less susceptible to noise than an AM signal?

11. (a) What is meant by energy density of a parallel plate capacitor? Derive its expression also.
(b) What is the area of the plates of a 2 Farad parallel plate air capacitor, given that the separation between the plates is 0.5 cm?

12. (a) For the given carbon resistor, let the first strip be yellow, second strip be red, third strip be orange and forth be gold. What is its resistance? (b) What are thermistors?

13. State Ampere's circuital law. Also find the expression for the magnetic field due to the infinite long straight wire carrying current by using this law.

14. (a) What do you mean by hypermetropia? What are its possible cause and how it is corrected?
(b) A hypermetropic person whose near point is at 100 cm wants to read a book at 25 cm. Find the nature and power of the lens needed.

15. The work function for the surface of aluminium is 4.2 eV. How much potential difference will be required to stop the emission of maximum energy electrons emitted by the light of 2000 $\overset{0}{A}$ wavelength? What will be the wavelength of that incident light for which stopping potential will be zero? Given that h = 6.6 $\times 10^{-34}$ Js. C = 3 $\times 10^{8}$ m/s

16. Write down the six properties of electric field lines.

17. Derive an expression for the electric field intensity due to two thin infinite parallel sheets of charge.

18. (a) Define current density and conductance.
(b) Derive the relation between current density, conductance and electric field.

19. (a) The connecting wires are of copper. Why?
(b) Calculate the resistivity of the material of wire 1 m long, 0.4 mm in diameter and having resistance of 2 ohm.

20. (a) A transistor does not work in railway carriage. Why?
(b) A common emitter amplifier is designed with npn transistor (α = 0.99). The input impedance is 1 kΩ and load is 10 kΩ. Find the voltage gain and power gain.

21. (a) What do you mean by modulation and demodulation? Explain.
(b) An audio signal of amplitude 0.1 V is used in amplitude modulation of a carrier wave of amplitude 0.2 V. Calculate the modulation index.

22. (a) Define decay constant.
(b) The sequence of decay of radioactive nucleus is $D \xrightarrow{\alpha} D_1 \xrightarrow{\beta} D_2 \xrightarrow{\alpha} D_3 \xrightarrow{\alpha} D_4$
If nucleon number and atomic number of D_2 are 176 and 71 respectively, what are their values for D and D_4?

23. Ram and Shyam went to the trade fair. They were busy in a crowded corner where the balloons were sold. A child was seen troubling his parent and crying for something. On seeing this, Ram went to the child and said that he would perform a trick with balloons. Ram took two balloons and Shyam helped him to inflate and tie. When the balloons were rubbed with the sweater he was wearing, they were attracted. When taken nearer to wall, the balloons got stuck. The child enjoyed and stopped crying.
(a) Give two values of Ram and Shyam.
(b) How did the balloons get attracted? Will they repel also?

24. (a) What is de Broglie hypothesis? Derive the formula for de Broglie wavelength.
(b) Find the de Broglie wavelength associated with a hydrogen molecule moving with a thermal velocity of 3km/s.

25. (a) What are features of Rutherford's atom model?
(b) The wavelength of K_α line for copper is 1.36 $\overset{0}{A}$. Calculate the ionization potential of a K shell electron in copper.

26. (a) Explain the distinction between conductors, semiconductor and insulators on the basis of their energy bands.
(b) The number densities of electrons and holes in pure silicon at 27°C are equal and its value is 2.0 $\times 10^{-16}$ m^{-3}. On doping with indium, the hole density increases to 4.5 $\times 10^{22}$ m^{-3}, find the electron density in dopped silicon.

SAMPLE PAPER-02 (solved)

PHYSICS (Theory)

Class – XII

Time allowed: 3 hours | Maximum Marks: 70

Solutions

1: To store the charge and electricity.

2: $v_d = \frac{i}{nAe} = v$

$v_d^{`} = \frac{2i}{n(4A)e} = \frac{1}{2}\frac{i}{nAe} = \frac{v}{2}$

3: The next nucleus can decay any time.

4: Zero

5: The both the surfaces of sun glasses are curved. Also, $R_1 = R_2$

As $P = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

P = 0.

6: The electric dipole moment is defined as the product of either cahrge and the distance between the two charges.

$\vec{p} = q \times 2\vec{a}$, where 2a is the seperation between the two charges

It is a vector quantity.

7: (i) Electric field is due to charges at rest as well as in motion, whereas magnetic field is due to a magnet or current flowing through a conductor.

(ii) The strength of electric field at a point decreases with the dielectric medium but the strength of magnetic field increases when a prmeable medium is inserted there.

(iii) The electric lines of force representing the electric field do not form a closed path, whereas the magnetic lines of force form a close path.

8: v = 2 × 10^8 m/s, c = 3 × 10^8 m/s

$\mu = \frac{c}{v} = \frac{3\times 10^8}{2\times 10^8} = 1.5$

Real depth, x = 6.0 cm, Apparent depth, y = ?

$\mu = \frac{x}{y}$

$y = \frac{x}{\mu} = \frac{6}{1.5} = 4 \text{ cm}$

Rise in the position of the dot = x – y = 6 – 4 = 2 cm

9: $E = h\nu - \phi_0$

$2\ eV = 8\ eV - \phi_0$

Or, $\phi_0 = 8 - 2 = 6\ eV$

Now, $E' = h\nu' - \phi_0 = h \times 1.25\nu_0 - \phi_0 = 1.25 \times 8 - 6 = 4\ eV$.

10: In FM transmission, message is in the form of frequency variation of carrier waves. During the process of modulation, noise gets amplitude modulated, changing the amplitude of carrier waves. Obviously, the message signal, in the form of frequency variations, is not affected. That is why FM signal is less susceptible to noise than an AM signal.

11: (a) It is defined as the total energy stored per unit volume of the capacitor.

Expression:

$$u = \frac{\text{total energy(U)}}{\text{volume(V)}} = \frac{\frac{1}{2}CV^2}{Ad} = \frac{1}{2}\left(\frac{\epsilon_0 A}{d}\right)\left(\frac{E^2 d^2}{Ad}\right)$$

$$u = \frac{1}{2}\epsilon_0 E^2$$

(b) C = 2 Farad, d = 0.5 cm = 5×10^{-3} m, $\epsilon_0 = 8.85 \times 10^{-12}\ C^2N^{-1}m^{-2}$, A = ?

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

$$A = \frac{Cd}{\epsilon_0} = \frac{2 \times 5 \times 10^{-3}}{8.85 \times 10^{-12}} = 1.13 \times 10^9\ m^2.$$

12: (a) As we know that the numbers for yellow, red and orange are 4, 2 and 3. Gold represents tolerance of ± 5%.

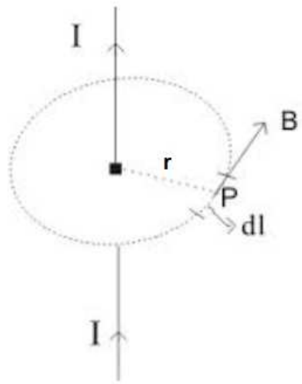
Thus, the value of resistance is $42 \times 10^3\ \Omega \pm 5\%$.

(b) A thermistor is a heat sensitive device whose resistivity changes very rapidly with change of temperature.

13: It states that the line integral of magnetic field induction $\vec{B}$ around a closed path in vacuum is equal to μ_0 times the total current I threading the closed path.

Expression for the magnetic field:

Consider an infinite long straight wire lying in the plane of paper. Let I be the current flowing through it from X to Y. A magnetic field is produced which is has the same magnitude at all the points that are at the same distance from the wire, i.e., the magnetic field has cylindrical symmetry around the wire.



Let P be a point at a perpendicular distance r from the straight wire and $\vec{B}$ be the magnetic field at point P. Now consider an ampereian loop as a circle of radius r, perpendicular to the plane of paper with centre on the wire such that point P lies on the loop. The magnitude of the magnetic field is same at all points on this loop. The magnetic field is tangential to the circumference of the circular loop. The line integral $\vec{B}$ round the closed loop is:

$$\oint \vec{B}.d\vec{l} = \oint B\,dl\,Cos0° = B\oint dl = B\,2\pi r$$

Now by using the Ampere's circuital law

$$\oint \vec{B}.d\vec{l} = \mu_0 I$$

$$B\,2\pi r = \mu_0 I$$

or $B = \dfrac{\mu_0 I}{2\pi r} = \dfrac{\mu_0}{4\pi}\dfrac{2I}{r}$,

14: (a) It is the defect of human eye by virtue of which the eye can see clearly the far off objects but the nearby objects cannot be seen clearly. In case of hypermetropia, the near point shifts away from the eye.
The main causes of this defect is:
(i) contraction in the size of the eye ball (ii) increase in the focal length of eye lens.
To correct this defect, the person has to use the spectacles with convex lens of suitable focal length.
(b) u = - 25 cm, v = - 100 cm, f = ?
By using lens equation,

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

$$\frac{1}{f} = \frac{1}{25} - \frac{1}{100} = \frac{3}{100}$$

f = 100/3 = 33.3 cm
P = 100/f = 100/(100/3) = 3 D.

15: ϕ_0 = 4.2 eV = 4.2 × 1.6 × 10^{-19} J, λ = 2000 $\overset{0}{A}$ = 2000 ×10^{-10} m
Maximum kinetic energy of photoelectrons

$$K_{max} = \frac{hc}{\lambda} - \phi_0 = \frac{6.6\times10^{-34}\times3\times10^{8}}{2000\times10^{-10}} - 4.2\times1.6\times10^{-19} = 3.18\times10^{-19}\text{ J}$$

Stopping potential, $V_0 = \dfrac{K_{max}}{e} = \dfrac{3.8\times10^{-19}}{1.6\times10^{-19}} = 11.9875$ V

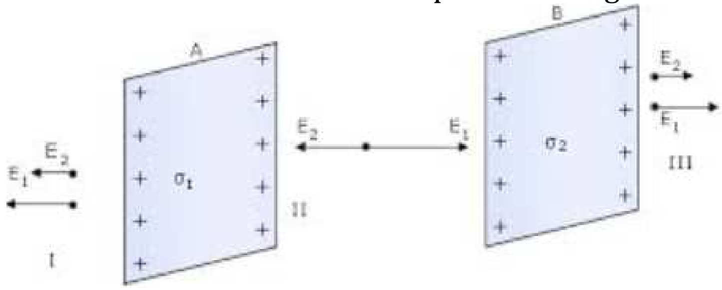
For the threshold wavelength λ_0, the stopping potential is zero.

$$\lambda_0 = \frac{hc}{\phi_0} = \frac{6.6\times10^{-34}\times3\times10^{8}}{4.2\times1.6\times10^{-19}} = 2.946\times10^{-7}\,m = 2946\,\overset{0}{A}$$

16: The properties of electric field lines are as follows:
(i) The electric field lines are discontinuous curves.
(ii) The tangent to the electric line of ofrce at any point gives the direction of electric field at that point.
(iii) No two electric lines of force intersect can each other.
(iv) The electric field lines are always normal to the surface of a conductor.
(v) The electric field lines contract longitudinally.

(vi) The electric field lines exert a lateral pressure on each other.

17: Let A and B be two thin infinite parallel charged sheets held parallel to each other.



Let, σ_1 = uniform surface density of charge on A, σ_2 = uniform surface density of charge on B

Now by using the superposition principle, we can calculate the electric field. By the convention, a field pointing from left to right is taken as positive and the one pointing from right to left is taken as negative. Here we assume that $\sigma_1 > \sigma_2 > 0$.

In region I: $E_I = -E_1 - E_2 = \frac{-\sigma_1}{2\epsilon_0} - \frac{\sigma_2}{2\epsilon_0} = \frac{-1}{2\epsilon_0}(\sigma_1 + \sigma_2)$

In region II: $E_{II} = E_1 - E_2 = \frac{\sigma_1}{2\epsilon_0} - \frac{\sigma_2}{2\epsilon_0} = \frac{1}{2\epsilon_0}(\sigma_1 - \sigma_2)$

In region III: $E_{III} = E_1 + E_2 = \frac{\sigma_1}{2\epsilon_0} + \frac{\sigma_2}{2\epsilon_0} = \frac{1}{2\epsilon_0}(\sigma_1 + \sigma_2)$

In some special cases, let $\sigma_1 = \sigma$ and $\sigma_2 = -\sigma$

So, $E_I = 0$

$E_{II} = \frac{2\sigma}{2\epsilon_0} = \frac{\sigma}{\epsilon_0}$ = a constant

$E_{III} = 0$

18: (a) The current density at a point in a conductor is defined as the amount of current flowing per unit area of the conductor around that point provided the area is held in a direction normal to the current. It is denoted by J.

density = Electric current / Area

It is a vector quantity and its unit is Ampere/metre^2.

The reciprocal of resistance is called conductance. It is denoted by G.

Conductance = 1 / resistance

Its unit is mho or siemen.

(b) As we know that, $I = neAv_d$

$I = nAe\left(\frac{eE}{m}\tau\right) = \frac{nAe^2\tau E}{m}$

$\frac{I}{A} = \frac{ne^2\tau E}{m}$

$J = \frac{I}{A} = \frac{1}{\rho}E \qquad \left(\because \rho = \frac{m}{ne^2\tau}\right)$

$J = \sigma E \qquad \left(\because \sigma = \frac{1}{\rho}\right)$

It is also called as the microscopic form of Ohm's law.

19: (a) The electrical conductivity of copper is high. Therefore, it conducts the current without offering much resistance. The copper being diamagnetic material does not get magnetized due to current through it and hence does not disturb the current I the circuit.
(b) Here, l = 1 m, D = 0.4×10^{-3} m = 4×10^{-4} m, R = 2 ohm

Area of crossection, A = $\frac{\pi D^2}{4} = \frac{\pi(4\times10^{-4})^2}{4} = 4\pi\times10^{-8}\ m^2$

Now, $\rho = \frac{RA}{l} = \frac{2\times4\pi\times10^{-8}}{1} = 2.514\times10^{-7}\ \Omega m$

20: (a) The railway carriage works as an electric screen. The electric field inside the carriage is zero and any change from outside in electric field cannot enter the carriage. Hence the electromagnetic signals do not find their entry in the railway carriage. Due to this, the transistor does not work in railway carriage.

(b) $\beta = \frac{\alpha}{1-\alpha} = \frac{0.99}{1-0.99} = 99$

Volatge gain, A_v = $\beta\frac{R_0}{R_i} = 99\times\frac{10\times10^3}{1\times10^3} = 990$

Power gain = $\beta^2\frac{R_0}{R_i} = (99)^2\times\frac{10\times10^3}{1\times10^3} = 98010$

21: (a) Modulation is the process of superimposing the low frequency message signal on a high frequency wave. The resulting wave is the modulated wave which is to be transmitted.
Demodulation is the reverse process of modulation. It is the phenomenon of retrieval of information from modulated wave at the receiver.
(b) Here, A_m = 0.1 V, A_c = 0.2 V

$\mu = \frac{A_m}{A_c} = \frac{0.1}{0.2} = 0.5$

22: (a) The decay constant of a radioactive element is the reciprocal of the time during which the number of atoms left in the sample reduces to 1/e times the original number of atoms in the sample.
(b) As the mass number of each α particle is 4 units and its charge number is 2 units, therefore, for D_4
A = 176 – 8 = 168, Z = 71 – 4 = 67
Now, charge number of β is -1 and its mass number is zero, therefore, for D
A = 176 + 0 + 4 = 180, Z = 71 – 1 + 2 = 72

23: (a) Presence of mind and knowledge of static electricity.
(b) When balloons were rubbed with woolen sweater, it becomes negatively charged. When taken nearer the wall, positive charges are induced by electrostatic induction on that part of the wall, so gets attracted. Yes, when the bodies are similar charged they repel.

24: (a) According to de Broglie, a moving material particle sometimes acts as a wave and sometimes acts as a particle or a wave is associated with moving material particle which controls the particle in every respect. The wave associated with the moving particle is called matter wave or de Broglie wave.

Derivation: According to Plank's quantum theory, the energy of a photon of a radiation of frequency ν and wavelength λ is

$E = h\nu$ .....(1)

Where, h is the Plank's constant. If photon is considered to be a particle of mass m, the energy associated with it, according to Einstein mass energy relation, is given by

$E = mc^2$ .....(2)

From (1) and (2), we get

$h\nu = mc^2$

$m = \frac{h\nu}{c^2}$ .....(3)

Since each photon moves with the same velocity c, therefore, momentum of photon,

p = mass × velocity

$p = \frac{h\nu}{c^2} \times c = \frac{h\nu}{c} = \frac{h}{\lambda}$

or, $\lambda = \frac{h}{p}$

This is the de Broglie wave equation for material particle.

(b) Here, $v = 3 \times 10^3$ m/s, Mass of hydrogen molecule = 2 amu = $2 \times 1.67 \times 10^{-27}$ kg

$$\lambda = \frac{h}{mv} = \frac{6.62 \times 10^{-34}}{2 \times 1.67 \times 10^{-27} \times 3 \times 10^3} = 6.6 \times 10^{-11} m$$

25 (a): The main features of the Rutherford's atom model are given below:

(i) Every atom consists of a tiny central core, called the atomic nucleus, in which the entire positive charge and almost entire mass of the atom are concentrated.

(ii) The size of nucleus is of the order of 10^{-15} m, which is very small as compared to the size of the atom which is of the order of 10^{-10} m.

(iii) The atomic nucleus is surrounded by certain number of electrons. As atom on the whole is electrically neutral, the total negative charge of electrons surrounding the nucleus is equal to total positive charge on the nucleus.

(iv) These electrons revolve around the nucleus in various circular orbits as do the planets around the sun. The centripetal force required by electron for revolution is provided by the electrostatic force of attraction between the electrons and the nucleus.

(b): From the relation, $\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

For K_α line, $n_1 = 1$, $n_2 = 2$

$$\frac{1}{\lambda} = RZ^2\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = \frac{3}{4}RZ^2$$

$$RZ^2 = \frac{4}{3\lambda}$$

Ionisation energy of K shell electron is

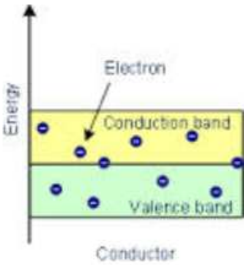
$$E=\frac{2\pi^2 mK^2Z^2e^4}{h^2}\left(\frac{1}{1^2}-\frac{1}{\infty^2}\right)=\frac{2\pi^2 mK^2Z^2e^4}{h^2(ch)}(ch)=RZ^2(ch)$$

By using equation (1), $E=\frac{4}{3\lambda}(ch)=\frac{4\times3\times10^8\times6.63\times10^{-34}}{3\times1.38\times10^{-10}}=19.5\times10^{-16}\,J$

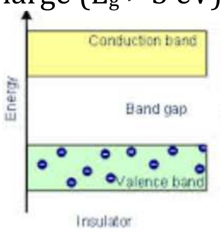
$$E=\frac{19.5\times10^{-16}}{1.6\times10^{-19}}eV=1.22\times10^4 eV$$

So, the ionization potential = 1.22×10^4 V

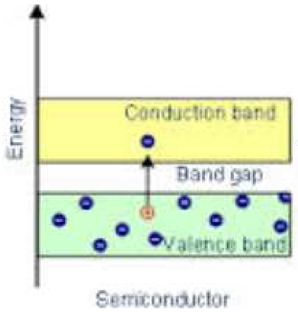
26 (a): Metals: The energy band diagram for a metal is such that either the conduction band is partially filled with electrons, or the conduction and valence band partly overlap each other and there is no forbidden energy gap in between as shown in the diagram.



Insulators: The energy band diagram of insulators is shown in the diagram given below. Here, the valence band is completely filled, the conduction band is empty and the energy gap is quite large (E_g > 3 eV).



Semiconductors: The energy band diagram of a semiconductor is shown below. Here, the valence band is totally filled and the conduction band is empty but the energy gap between the conduction band and the valence band is quite small.



(b) Here, $n_i = 2\times10^{16}\,m^{-3}$, $n_h = 4.5\times10^{22}\,m^{-3}$

$$n_e=\frac{n_i^2}{n_h}=\frac{(2\times10^{16})^2}{4.5\times10^{22}}=8.89\times10^9\,m^{-3}$$