SAMPLE PAPER-05

PHYSICS (Theory)

Class – XII

Time allowed: 3 hours Maximum Marks: 70

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 $\mu = \frac{c}{v} = \frac{1}{SinC}$

Sin C = $\frac{v}{c} = \frac{1.5\times10^8}{3\times10^8} = 0.5$

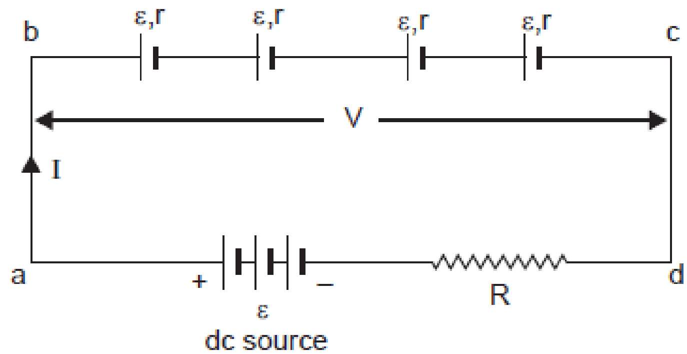
C = $Sin^{-1}(0.5)$ = 30°

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. The circuit arrangement as shown below



b. Applying Kirchhoff's second law to the circuit abcda.

$$-n\varepsilon - I(nr) - IR + \varepsilon' = 0$$

$$I = \frac{\varepsilon' - n\varepsilon}{R + nr}$$

(i) Charging current

$$I = \frac{\varepsilon' - n\varepsilon}{R + nr}$$

(ii) Potential difference across the combination V is given by

$$-V - IR + \varepsilon' = 0$$

$$V = \varepsilon' - IR$$

$$V = \varepsilon' - \frac{(\varepsilon' - n\varepsilon)}{R + nr}$$

$$V = \frac{\varepsilon'(R + nr) - \varepsilon' + n\varepsilon}{R + nr}$$

$$V = \frac{\varepsilon'(R + nr - 1) + n\varepsilon}{R + nr}$$

12. $R_{BC} = R_{AC} - R_{AB} = (2000 - 500)\Omega = 1500\Omega$

Equivalent resistance R_p of parallel combination of 1500Ω and 500Ω is

$$\frac{1500 \text{ x } 500}{1500 + 500}\Omega = 375\Omega$$

Total resistance of circuit $= (500 + 375)\Omega = 875\Omega$

Current $I = \frac{50}{875} A = \frac{2}{35} A$

(i) Potential drop across R_L is the same as the potential drop across the parallel combination.

Potential drop across $R_L = 50 - V_{AB}$

$$= 50 - \frac{2}{35} X\, 500 = 21.43V$$

(ii) After the load has been removed.

$$I' = \frac{50}{2000} A = \frac{1}{40} A$$

$$R'_{BC} = \frac{40}{1/40} \Omega = 1600\Omega$$

Or

Total resistance = $\frac{4 \text{ x } 4}{4+4} = 2\Omega$

Current $I = \frac{10V}{2\Omega} = 5A$

Since the resistance of both the branches is equal therefore the current of 5A shall be equally distributed.

Current through each branch $= \frac{5}{2} A = 2.5A$

$$V_C - V_A = 2.5 \text{ x } 1 = 2.5$$
$$V_C - V_B = 2.5 \text{ x } 3 = 7.5$$
$$V_A - V_B = (V_C - V_B) - (V_C - V_A) = 7.5V - 2.5V = 5.0V$$

13. Given d = 0.15 mm = $0.15 \text{ x } 10^{-3}$ m

$\lambda = 450nm = 450 \text{ x } 10^{-9} m, D = 1.0m$

a. Distance of second bright maximum from central maximum (n=2)

$$y_2 = \frac{nD\lambda}{d} = \frac{2 \text{ x } 1.0 \text{ x } 450 \text{ x } 10^{-9}}{0.15 \text{ x } 10^{-3}} m = 6 \text{ x } 10^{-3} m = 6mm$$

Distance of second dark fringe from central maximum(n=2)

$$y'_2 = \left(n - \frac{1}{2}\right)\frac{D\lambda}{2} = \left(2 - \frac{1}{2}\right)\frac{1.0 \text{ x } 450 \text{ x } 10^{-9}}{0.15 \text{ x } 10^{-3}} m$$
$$= 4.5 \text{ x } 10^{-3} m = 4.5mm$$

b. If screen is moved away from the slits, D increases, so fringe width $\beta = \frac{D\lambda}{d}$ increases.

14. $\vec{F} = q(\vec{v} \text{ x } \vec{B})$

a. Force acts in a direction normal to the velocity vector. Thus work done by the force is zero and kinetic energy remains same.

b. We know that $P = \vec{F}.\vec{v}$

$P = Fv\cos\theta$

At any instant of time force and velocity vector are mutually perpendicular (θ=90^0).

So the instantaneous power is zero.

15. Given

$V = \sqrt{3}H$

Total intensity of earth's magnetic field = 0.4 G

$$B_e = \sqrt{V^2 + H^2}$$
$$0.4 = \sqrt{(\sqrt{3}H)^2 + H^2}$$
$$0.4 = \sqrt{3H^2 + H^2}$$
$$0.4 = 2H$$
$$H = 0.2G$$
$$V = \sqrt{3} \text{ x } 0.2\text{G}$$

a. Angle of dip

$$\delta = \tan^{-1}\left(\frac{V}{H}\right)$$

$$\delta = \tan^{-1}\left(\frac{\sqrt{3}H}{H}\right) = \tan^{-1}(\sqrt{3})$$

$$\delta = 60^0$$

b. The horizontal component of earth's magnetic field H = 0.2 G

16. As

a. Unknown emf ε_2 is given by

$$\frac{\varepsilon_2}{\varepsilon_1} = \frac{l_2}{l_1} \Rightarrow \varepsilon_2 = \frac{l_2}{l_1}\varepsilon_1$$

Given $\varepsilon_1 = 1.5V, l_1 = 60cm, l_2 = 80cm$

$$\therefore \varepsilon_2 = \frac{80}{60} \text{ x } 1.5\text{V} = 2.0\text{V}$$

b. The circuit will not work if emf of driver cell is 1 V(less than that of cell in secondary circuit), because total voltage across wire AB is 1 V which cannot balance the voltage 1.5 V.

c. No, since at balance point no current flows through galvanometer G cell remains in open circuit.

17.

$m = \frac{f}{u+f}$

When image is real, m = – n.

$\therefore \quad -n = \frac{f}{u+f} \quad or \quad u+f = -\frac{f}{n} \quad or \quad u = -\left(f + \frac{f}{n}\right) \ldots.(i)$

When image is virtual, $m = n$.

$\therefore \quad n = \frac{f}{u+f} \quad or \quad u+f = -\frac{f}{n} \quad or \quad u = -\left(f - \frac{f}{n}\right) \ldots.(ii)$

It follows from (i) and (ii) that the magnitude of the object distance is $\left(f \pm \frac{f}{n}\right)$.

Focal length of lens = $\frac{1}{2.5} m = \frac{1}{2.5} \times 100\ cm$

Now, $\pm 4 = \frac{40}{u+40}$

u = – 30cmor – 50 cm

18. The de-Broglie wavelength λ of electron

$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}}$

(Since k=eV and K = $\frac{1}{2}mv^2 = \frac{p^2}{2m}$, $p = \sqrt{2mK} = \sqrt{2meV}$)

$\lambda = \frac{h}{\sqrt{2meV}}$

Putting values of h, m and e we get

$\lambda = \frac{6.626 \text{ x } 10^{-34}}{\sqrt{2 \text{ x } 9.1 \text{ x } 10^{-31} \text{ x } 1.6 \text{ x } 10^{-19} \text{ x V}}}$

$\lambda = \frac{1.227}{\sqrt{V}}$

Given V = 10 kV = 10 x 10^3 V = 10^4 V

$$\lambda = \frac{1.227}{\sqrt{10^4}} = \frac{1.227}{100} = 0.01227nm$$

λ =0.01227 x 10^{-9} m = 0.1227 x 10^{-10} m

19.

a. The energy of photon of wavelength (275 nm) in terms of eV can be given as

$$E = \left(\frac{\lambda c}{e\lambda}\right)eV$$

$$E = \frac{6.6 \text{ x } 10^{-34} \text{ x } 10^{8}}{1.6 \text{ x } 10^{-19} \text{ x } 275 \text{ x } 10^{-9}}$$

$$E = \frac{19.8}{1.6 \text{ x } 275} \text{ x } 10^{2}eV = 435eV$$

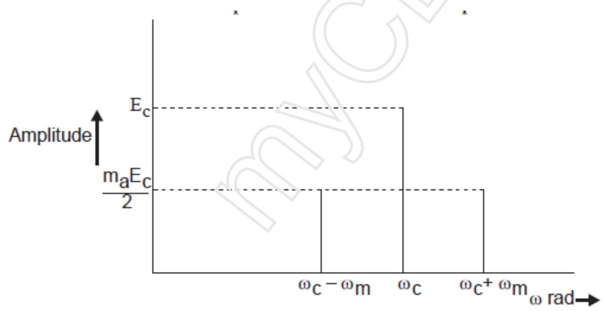
The energy of photon in transition $B\Delta E = [0eV - (-4.5eV)] = 4.5eV$. Hence transition B is possible.

b. The wavelength of the photon in a transition is given by $\lambda = \frac{\lambda c}{\Delta E}$

(i) Maximum wavelength of photon is possible for transition having minimum ΔE , so transition 'A' is possible with ΔE = 2eV.

(ii) Minimum wavelength of the photon is possible for transition having maximum energy difference. So transition D is possible with ΔE =10eV.

20. Plot of variation of amplitude versus ω for amplitude modulated wave is shown below.



Modulation Index – the ratio of amplitude of modulating signal to the amplitude of carrier wave is called modulation index.

$$m_a = \frac{E_m}{E_c}$$

For effective amplitude modulation index determines the distortions, so its value is kept< 1 for avoiding distortions.

21.

S.No	Nuclear Fission	Nuclear Fusion
1	It's a process in which a heavy unstable nucleus disintegrates into two or more lighter and relatively stable nuclei.	It's a process in which two small, lighter nuclei combine to form stable heavy nucleus.
2	The product of nuclear fission is radioactive in nature	The product is stable and non-radioactive in nature.
3	It can be controlled and hence can be used for peaceful purposes.	It is yet to be controlled.

22. Given

R = 1 $k\Omega$ = $10^3\,\Omega$

C = 10pF = 10 x 10^{-12} F = 10^{-11} F

RC = 10^3 x 10^{-11} s = 10^{-8} s

We find that $\frac{1}{f_c}$ is not less than RS as is required for demodulation. Therefore, the arrangement is not good.

For satisfactory arrangement, let us try

$C = 1\mu F = 10^{-6} F$

$\therefore RC = 10^3 \text{ x } 10^{-6} s = 10^{-3} s$

Now $\frac{1}{f_c} (= 10^{-5} s) << RC (= 10^{-3} s)$

The condition is satisfied. This is good enough for demodulation.

23.

a. The values shown by Sara are

i) High degree of general awareness.

ii) Ability to convince someone

iii) Thinking skills

iv) Concern for her friends.

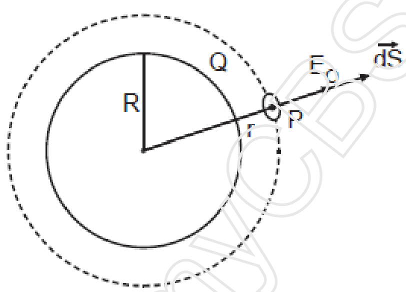
b. The size of the obstacle should be comparable to the wavelength of the light wave in order to obtain an observable diffraction pattern. Size of the wall is 7 m, which is comparable enough with sound wave but not with the light wave. so the two students cannot see each other but can talk to each other.

24.

a. Electric field intensity at a point outside a uniformly charged thin spherical shell- consider a uniformly charged thin spherical shell of radius R carrying charge Q. to find the electric field outside the shell, we consider a spherical Gaussian surface of radius (>R), Concentric with given shell. If $\vec{E}$ is electric field outside the shell, then by symmetry electric field strength has same magnitude E_0 on the Gaussian surface and is directed radially outward. Also the directions of normal at each point is radially outward, so angle between $\overrightarrow{E_i}$ *and* $d\vec{S}$ is zero at each point. Hence, electric flux through Gaussian surface will be,

$$\oint S \vec{E}.d\vec{S}$$

$$\oint E_0 dS \cos 0 = E_o.4\pi r^2$$



Now Gaussian surface is outside the given charged shell, so charge enclosed by bGaussian surface Q. hence Gaus theoerm

$$\oint \overrightarrow{E_o}.d\vec{E} = \frac{1}{\varepsilon_o} \text{ x charged enclosed}$$

$$E_0 4\pi r^2 = \frac{1}{\varepsilon_0} \text{ x Q}$$

$$\mathrm{E}_0 = \frac{1}{4\pi\varepsilon_o}\frac{Q}{r^2}$$

Thus electric field outside a charged thin spherical shell is the same as if the whole charge Q is concentrated at the centre.

If σ is the surface charge density of the spherical shell then,

$$\phi = 4\pi R^2 \sigma C$$

$$E_0 = \frac{1}{4\pi\varepsilon_0}\frac{4\pi R^2\sigma}{r^2} = \frac{R^2\sigma}{\varepsilon_0 r^2}$$

b. Given

$\sigma = 100\mu C / m^2 = 100 \text{ x } 10^{-6} C / m^2$

Diameter D = 2 R = 2.5 m

i) Charge on sphere Q = $\sigma.4\pi R^2 = \sigma.\pi(2R)^2$

$$= (100 \text{ x } 10^{-6} C / m^2) \text{ x } 3.14 \text{ x } (2.5 \text{ m})^2$$
$$= 19.625 \text{ x } 10^{-4} C$$
$$= 1.96 mC$$

ii) Electric flux passing through the sphere

$$\phi = \frac{1}{\varepsilon_0}(Q) = \frac{1}{8.86 \text{ x } 10^{-12}} \text{ x } (1.96 \text{ x } 10^{-3})$$
$$= 2.21 \text{ x } 10^8 Nm^2 C^{-1}$$

Or

Radius of the inner sphere r_2 = 12cm = 0.12m

Radius of the outer sphere r_1 = 13 cm = 0.13 m

Charge on the inner sphere q = 2.5μC = 2.5 x 10^{-6}C

Dielectric constant of a liquid ε_r = 32

(a) Capacitance of the capacitor is given by the relation

$$C = \frac{4\pi\varepsilon_0\varepsilon_1 r_1 r_2}{r_1 - r_2}$$

Where ε0 = permittivity of the free space = 8.85 x 10^{-12} $C^2 N^{-1} m^{-2}$

$$\frac{1}{4\pi\varepsilon_0} = 9x10^9 Nm^2C^{-2}$$

$$C = \frac{32 \text{ x } 0.12 \text{ x } 0.13}{9 \text{ x } 10^9 \text{x } (0.13 - 0.12)}$$

$C = 5.5x10^9 F$

Hence the capacitance of the capacitor is approximately 5.5 x 10^{-9} F

(b) Potential of the inner sphere is given by

$$r = \frac{q}{C}$$

$$r = \frac{2.5 \text{ x } 10^{-6}}{5.5 \text{ x } 10^{9}} = 4.5 \text{ x } 10^2 \text{V}$$

Hence, the potential of the inner sphere is 4.5 x 10^2V.

(c) Radius of an isolated sphere r = 12 x 10^{-2}m

Capacitance of the sphere is given by the reaction,

$C' = 4\pi\varepsilon_0 r$

$= 4\pi \text{ x } 8.85 \text{ x } 10^{-12} \text{ x } 12 \text{ x} 10^{-12}$

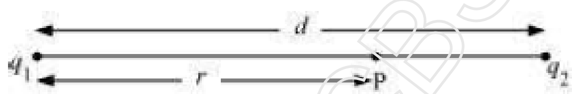
$= 1.33 \text{ x } 10^{-11}$F

The capacitance of the isolated sphere is less in comparison to the concentric spheres. This is because the outer sphere of the concentric spheres is earthed. Hence the potential difference is less and the capacitance is more than the isolated sphere.

25. There are two charges, q_1 = 5 x 10^{-8}C andq_2 = -3 x 10^{-8} C

Since between the two charges, d = 16 cm = 0.16 m.

Consider a point P on the line joining the two charges, as shown in the given figure.



Distance of point P from charge q_1 = r

Let the electric potential (V) at point P be zero.

Potential at point P is the sum of potentials caused by charges q_1 and q_2 respectively.

$$V = \frac{q_1}{4\pi\varepsilon_0 r} + \frac{q_2}{4\pi\varepsilon_0 (d-r)} ----------(1)$$

Where ε_0 = permittivity of free space. For V =0 , equation (1) reduces to

$$\frac{q_1}{4\pi\varepsilon_0 r} = -\frac{q_2}{4\pi\varepsilon_0 (d-r)}$$

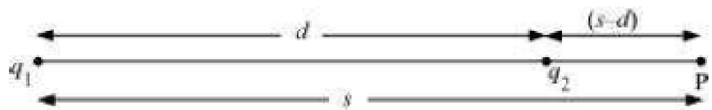
$$\frac{q_1}{r} = -\frac{q_2}{d - r}$$

Substituting the values, we get

R = 0.1 m = 10 cm

Therefore the potential is zero at distance of 10 cm from the positive charge between the charges.

Suppose point P is outside the system of two charges at a distance s from the negative charge, where potential is zero as shown in the figure.



For this arrangement, potential is given by

$$V = \frac{q_1}{4\pi\varepsilon_0 s} + \frac{q_2}{4\pi\varepsilon_0 (s - d)} ----------(2)$$

For V =0, equation (ii) reduce to,

$$\frac{q_1}{s} = -\frac{q_2}{(s - d)}$$

Substituting the values, we get

s = 0.4 m = 40 cm

Therefore, potential is zero at a distance of 40cm from the positive charge outside the system of charges.

Or

Capacitance between the parallel plates of the capacitor C = 8 pF

Initially distance between the parallel plates was d and it was filled with air. Dielectric constant of air k=1,

Capacitance C is given by formula

$$C = \frac{k\varepsilon_0 A}{d} = \frac{\varepsilon_0 A}{d} -------------- (1)$$

Where A = area of each plate and ε_0 = permittivity of free space.

If the distance between the plates is reduced to half, then new distance d′ = d/2

Dielectric constant of the substance filled in between the plates k′ = 6

$$C = \frac{k'\varepsilon_0 A}{d'} = \frac{6\varepsilon_0 A}{\frac{d}{2}} -------------- (2)$$

Taking ratios of equation (i) and (ii) we obtain

C′ = 2 x 6C

= 12 C

= 12 x 8 = 96 pF

Therefore, the capacitance between the plates is 96pF.

26.

a. No. However strong the magnet may be, current can be induced only by changing the magnetic flux through the loop.

b. No current is induced in eithercase. Current cannot be induced by changing the electric flux.

c. The induced emfis expected to be constant only in the case of the rectangular loop. In the case of circular loop, the rate of change of area of the loop during its passage out of the field region is not constant; hence induced emfwill vary accordingly.

d. The polarity of plate 'A' will be positive with respect to plate 'B' in the capacitor.

Or

As the rod is rotated, free electrons in the rod move towards the outer end due to Lorentz force and get distributed over the ring. Thus, the resulting separation of charges produces an emf across the ends of the rod. At a certain value of emf, there is no more flow of electrons and a steady state is reached. We know that, the magnitude of the emf generated across a length d*r*of the rod as it moves at right angles to the magnetic field is given by,

Dε = Bvdr, hence

$$\varepsilon = \int d\varepsilon = \int_0^R Bvdr = \int_0^R B\omega rdr = \frac{B\omega R^2}{2}$$

Substituting the value, we get 157 V.