# Stage III

# Sample Question Paper

**Fully Solved** *(Questions-Answers)*

# PHYSICS-XII

*A highly Simulated Practice Question Paper for* ***CBSE Class XII*** *Examination*

**Time : 3 hrs** **Max. Marks : 70**

## General Instructions

1. All questions are compulsory.
2. There are 29 questions in total. Questions 1 to 8 are very short answer questions and carry one mark each.
3. Questions 9 to 16 carry two marks each, questions 17 to 25 carry three marks each, question 26 carry four marks and questions 27 to 29 carry five marks each.
4. There is no overall choice. However, an internal choice has been provided in one question of two marks, one question of three marks and all three questions of five marks each. You have to attempt only one of the given choices in such questions.
5. Use of calculator is not permitted. However, you may use log tables if necessary.
6. You may use the following values of physical constants wherever necessary.
   $c = 3 \times 10^8 \text{ ms}^{-1}$, $h = 6.63 \times 10^{-34}$ Js, $e = 1.6 \times 10^{-19}$ C, $\mu_0 = 4\pi \times 10^{-7} \text{TmA}^{-1}$, $1/4\pi\varepsilon_0 = 9 \times 10^9 \text{ Nm}^2\text{-C}^{-2}$, $m_e = 9.1 \times 10^{-31}$ kg

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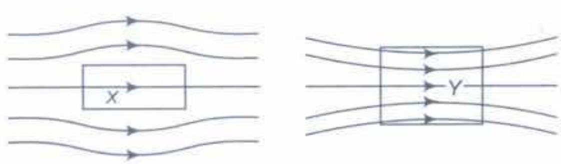
1. Which physical quantity has unit $JC^{-1}$? Is it a vector or a scalar quantity?
2. A toaster produces more heat than a light bulb when connected in parallel to a 220 V mains. Which of the two has greater resistance?
3. A uniform magnetic field gets modified as shown below, when two specimens $X$ and $Y$ are placed in it.

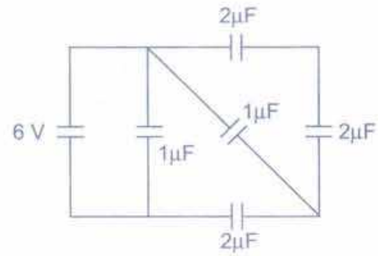



   Identify the two specimens $X$ and $Y$.
4. The polarising angle of a medium is 60°. What is the refractive index of the medium? **(Ans. 1.732)**
5. Plot a graph showing the variation of photoelectric current with anode potential for two light beams of same wavelength but different intensity.
6. Two nuclei have mass number in the ratio of 2 : 5. What is the ratio of their nuclear densities? **(Ans. 1 : 1)**

7. What is the order of energy gap in a semiconductor?

8. What type of modulation is required for television broadcast?

9. Find the total energy stored in the capacitors in the given network.




(Ans. $3 \times 10^{-5}$ J)

10. Write the relation for the force **F** acting on a charge carrier $q$ moving with a velocity **v** through a magnetic field **B** in vector notation. Using this relation, deduce the condition under which this force will be

(i) maximum (ii) minimum

11. An electric lamp connected in series with a capacitor and an AC source is glowing with of certain brightness. How does the brightness of the lamp change on reducing the

(ii) capacitance and (ii) frequency?

12. State two conditions for sustained interference of light. Also, write the expression for the fringe width.

13. The radii of curvature of both the surfaces of a lens are equal. If one of the surface is made plane by grounding, then will the focal length of lens change? Will the power change?

14. An $\alpha$-particle and a proton are accelerated from the state of rest through the same potential difference $V$. Find the ratio of de-Broglie wavelengths associated with them.

15. Define the term 'activity' of a radioactive substance. State its SI unit. Give a plot of activity of radioactive species *versus* time.

16. A parallel plate capacitor with air between the plates has a capacitance of 8 pF. The separation between the plates is now reduced by its half and the space between them is filled with a medium of dielectric constant 5. Calculate the value of the capacitance of the capacitor in the second case. (Ans. 80 pF)

OR

A 600 pF capacitor is charged by a 200 V supply. It is then disconnected from the supply and is connected to the another uncharged 600 pF capacitor. How much electrostatic energy is lost in the process? (Ans. $6 \times 10^{-6}$ J)

17. Name the constituent radiation of electromagnetic spectrum which

(i) is used for studying crystal structure.

(ii) is absorbed from sun light by ozone layer.

(iii) produces intense heating effect.

(iv) is used in cellular phones to transmit voice communication.

(v) is used for sterilizing surgical instruments.

(vi) is used for taking photograph in foggy season.

**18.** Distinguish between diamagnetic and ferromagnetic materials in respect of their

(i) intensity of magnetisation

(ii) behaviour in non-uniform magnetic field and

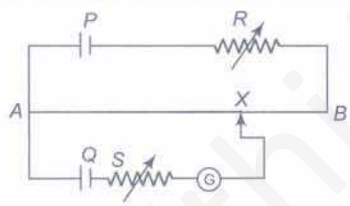
(iii) susceptibility.

**19.** In the potentiometer circuit shown, the balance point is at $X$. State with reason, where the balance point will be shifted when,

(i) resistance $R$ is increased, keeping all parameters unchanged.

(ii) resistance $S$ is increased, keeping $R$ constant.

(iii) cell $P$ is replaced by another cell whose emf is lower than that of cell $Q$.




**20.** A bar magnet $M$ is dropped so that it falls vertically through the coil $C$. The graph obtained for voltage produced across the coil *versus* time is shown in the figure.

(i) Explain the shape of the graph.

(ii) Why is the negative peak longer than the positive peak?

**21.** In a single slit diffraction pattern, how is the angular width of central bright maximum changed when

(i) the slit width is decreased

(ii) the distance between the slit and the screen is increased

(iii) light of smaller wavelength used.

Justify your answer.

**22.** Describe Davisson and Germer's experiment to demostrate the wave nature of electrons. Draw a labelled diagram of apparatus used.

OR

Derive Einstein's photoelectric equation and explain laws of photoelectric effect on its basis.

**23.** Prove that the instantaneous rate of change of the activity of a radioactive substance is inversely proportional to the square of its half-life.

**24.** Explain the working of a *p-n-p* transistor. Draw its input and output characteristics.

25. A particle of mass $m$ with charge $q$, moving with a uniform speed $v$, normal to a uniform magnetic field $B$, describes a circular path of radius $r$. Derive expressions for the

(i) time period of revolution and

(ii) kinetic energy of the particle.

26. Two best friends John and Jolly are students of IX class. John wants to be an astronaunt but he does not anything about astronomy. So, he shared his desire with his friend Jolly. Jolly asked him to take advice from his teachers.

(i) What would be the suggestion of this teacher?

(ii) An astronaunt is looking down on the earth's surface from with the eyelens having aperture of 5mm from a space shuttle at an altitude of 500 km and the wavelength of visible light is 500 nm, the aslronaunts will be able to find the linear objects of the size of about. **(Ans. 50 m)**

27. An electric dipole of dipole moment **p** is placed in a uniform electric field **E**. Write the expression for the torque $\tau$ experienced by the dipole. Identify two pairs of perpendicular vectors in the expression. Show diagrammatically the orientation of the dipole in the field for which the torque is

(i) maximum (ii) half the maximum value (iii) zero.

OR

State Gauss's theorem. Using Gauss's theorem derive an expression for the electric field intensity at a point outside and inside the uniformly charged thin spherical shell.

28. (i) Derive the mirror formula which gives the relation between $f$, $v$ and $u$. What is the corresponding formula for a thin lens?

(ii) A 5 cm long needle is placed 10 cm from a convex mirror of focal length 40 cm. Find the position, nature and size of the image of needle. What happens to size of image when the needle is moved further away from the mirror. **(Ans. 8 cm)**

OR

With the help of a ray diagram, show the formation of image of a point object by refraction of light at a spherical surface, separating two media of refractive indices $n_1$ and $n_2$ ($n_2 > n_1$) respectively. Using this relation derive the relation

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{(n_1 - n_2)}{R}$$

29. What does the term LOS communication mean? Name the type of waves that are used for this communication. Give typical example with the help of suitable figure of communication systems that use space wave mode propagation.

OR

What is space wave propagation? Which two communication methods make use of this mode of propagation? If the sum of the heights of transmitting and receiving antennas in line of sight communication is fixed at $h$, show that the range is maximum when the two antennas have a height $\frac{h}{2}$ each.

# Sample Question Paper 13

**1.** Electric potential has the unit $JC^{-1}$ and it is a scalar quantity. **(1)**

**2.** As we know that the light bulb (domestic) are connected in series with the supply. Resistances in series with the supply associates more equivalent resistance and hence much power ($P = i^2R$).

When resistances are connected in parallel it associates less equivalent resistance and hence less power.

So, heat produced $\propto \frac{1}{R}$ for same voltage.

Obviously bulb has the greater resistance because $R$ for the bulb considered to be parallel with the supply of 220 V. **(1)**

**3.** $X$ is diamagnetic and $Y$ is paramagnetic because field inside diamagnetic material (*i.e.*, $X$) is weaker while field inside paramagnetic material (*i.e.*, $Y$) is stronger. **(1)**

**4.** According to Brewster's law

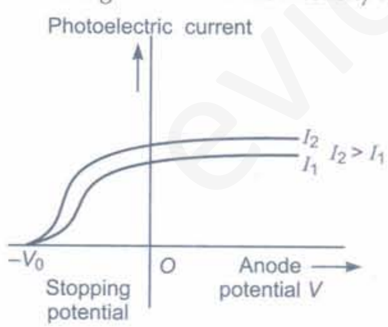
$$n = \tan i_p$$

Here given $i_p = 60°$

$\therefore \quad n = \tan 60° = \sqrt{3}$

$\Rightarrow \quad n = 1.732$ **(1)**

**5.** The plot showing the variation of photoelectric current with anode potential for two light beams of same wavelength but different intensity is as below




**(1)**

**6.** Nuclei having mass number in the ratio of 2 : 5.

As the density in mass per unit nucleon *i.e.*, proton or neutron). It is obviously true that mass of one nucleon is taken 1.

So their densities ratio will be 1:1. **(1)**

**7.** In energy band diagrams of semiconductor the energy gap between donor and conduction or between valance and acceptor is 0.01 eV.

*i.e.*, energy gap $= 1 \times 10^{-2}$ eV

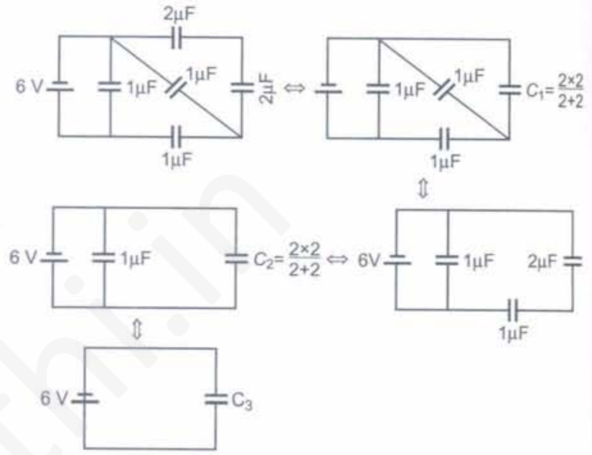
So, order of energy gap is $10^{-2}$. **(1)**

**8.** The frequency modulation is employed in television broadcast. **(1)**

**9.** As we know that energy spread in a capacitor is

$$U = \frac{1}{2} C_{eq} V^2$$

We have to find the equivalent capacitance for the given network in the question.




Here, $\quad C_3 = 1 + \frac{2}{3} = \frac{5}{3} \mu F = C_{eq}$ **(1)**

$$\therefore \quad U = \frac{1}{2} C_{eq} V^2 = \frac{1}{2} \times \frac{5}{3} \times 10^{-6} \times 6^2$$

$$= \frac{1}{2} \times \frac{5}{3} \times 10^{-6} \times 36$$

$$= 30 \times 10^{-6} = 3 \times 10^{-5} \text{ J}$$ **(1)**

**10.** Whenever a charge $q$ is moving inside the region of magnetic field with a velocity $v$. The force due to the magnetic field, on the charge is given by

$$\mathbf{F} = q\mathbf{v} \times \mathbf{B}$$

$$= qvB \sin\theta$$

(i) If $\theta = 90°$ *i.e.*, $\sin\theta = \sin 90° = 1$,

the force will be maximum and equal to $qvB$. **(1)**

(ii) If $\theta = 0°$ *i.e.*, $\sin\theta = \sin 0° = 0$,

the force will be minimum and equal to zero. **(1)**

**11.** (i) On reducing the capacitance the capacitive reactance ($X_C$) increases and therefore impedance ($Z$) of the circuit increases.

Due to increase in impedance, current $I = \frac{V}{Z}$, decreases and hence brightness of the bulb reduces. **(1)**

(ii) On reducing the frequency the capacitive reactance ($X_C$) and therefore impedance ($Z$) increases due to which current decreases and therefore brightness of the bulb reduces. (1)

**12.** Condition for sustained interference are

(i) The two sources of light must be coherent to emit light of constant phase difference.

(ii) The amplitude of electric field vector of interfering wave should be equal to have greater contrast between intensity of constructive and destructive interference. (1)

Now, for constructive interference

$$\frac{dY_n}{D} = n\lambda$$

$\therefore$ Fringe width of dark fringe

$$\beta = Y_{n+1} - Y_n = \frac{D\lambda}{d}(n+1) - \frac{Dn\lambda}{d} = \frac{D\lambda}{d}$$

For destructive interference

$$\frac{Y'_n d}{D} = (2n-1)\frac{\lambda}{2}$$

$\therefore$ Fringe width of bright fringe,

$$\beta' = Y'_{n+1} - Y'_n = \frac{(2n+1)D\lambda}{2d} - \frac{(2n-1)D\lambda}{2d}$$

$$\Rightarrow \quad \beta' = \frac{XD}{d}$$

$$\Rightarrow \quad \beta = \beta' \qquad (1)$$

**13.** By the formula

$$\frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$= (\mu - 1)\left[\frac{1}{R} - \left(\frac{1}{R}\right)\right] \qquad (\text{As } R_1 = R_2 = R)$$

$$\Rightarrow \quad P = \frac{2(\mu - 1)}{R}$$

Now if, $R_1$ or $R_2 = \infty$, then

$$\frac{1}{f'} = (\mu - 1)\left[\frac{1}{R_1} - 0\right] \qquad (1)$$

$$\Rightarrow \quad P' = \frac{(\mu - 1)}{R} = \frac{P}{2}$$

*i.e.*, power will be halved and hence $\frac{1}{f}$ will be halved.

$\Rightarrow$ Focal length will be doubled.

Here, obviously the power has been changed. (1)

**14.** Given $\alpha$-particle and proton are accelerated through the same potential difference $V$.

By de-Broglie equation

$$\lambda = \frac{h}{p} \quad \Rightarrow \quad \lambda = \frac{h}{\sqrt{2meV}}$$

If $m_p$ = mass of electron

the mass of $\alpha$-particle $= 4m_p$

If $e$ = charge on electron

the charge on $\alpha$-particle $= 2e$

$$\therefore \lambda_p = \text{wavelength for proton} = \frac{h}{\sqrt{2m_p eV}} \qquad (1)$$

$$\lambda_\alpha = \text{wavelength for } \alpha\text{-particle} = \frac{h}{\sqrt{2 \times 4m_p 2eV}}$$

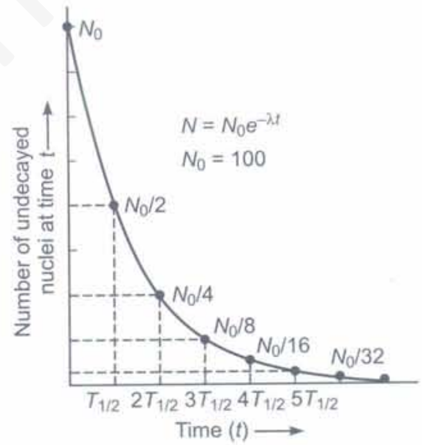
$$\Rightarrow \quad \frac{\lambda_p}{\lambda_\alpha} = \frac{h}{\sqrt{2m_p eV}} \times \frac{\sqrt{16m_p eV}}{h}$$

$$= \frac{4}{\sqrt{2}} = \frac{2\sqrt{2}}{1} = 2\sqrt{2}:1 \qquad (1)$$

**15.** The activity of a sample is defined as the rate of disintegration taking place in the sample of radio active substance.

SI unit of activity is becquerel (Bq), where, 1 Bq =1 disintegration per second.

The curve showing activity of a radioactive substance with time is shown below




Decay curve for a radioactive element (1)

**16.** Given, capacitance of capacitor

$$C = \frac{\varepsilon_0 A}{d} = 8 \text{ pF} \qquad \ldots\text{(i)}$$

(1/2)

where, $A$ and $d$ are area of each plate and separation between two plates.

Now, $$C' = \frac{K\varepsilon_0 A'}{d'} = \frac{5 \times \varepsilon_0 A}{(d/2)} = 10\left(\frac{\varepsilon_0 A}{d}\right) \qquad (1)$$

$$C' = 10\left(\frac{\varepsilon_0 A}{d}\right) = 10C$$

$$= 10 \times 8 \text{ pF} = 80 \text{ pF}$$

$$C' = 80 \text{ pF} \qquad (1/2)$$

OR

Initially, stored energy in capacitor

$$U_1 = \frac{1}{2}C_1V_1^2 = \frac{1}{2}\times 600\times 10^{-12}\times(200)^2 = 1.2\times 10^{-5}\,J$$
$$= 12\times 10^{-6}\,J \qquad (1)$$

Now, common potential difference after connecting other capacitor,

$$V = \frac{q_1+q_2}{C_1+C_2} = \frac{C_1V_1+0}{C_1+C_2} = \frac{600\times 10^{-12}\times 200}{(600+600)\times 10^{-12}} = 100\,V$$

∴ Final energy stor,

$$U_2 = \frac{1}{2}(C_1+C_2)V^2$$
$$= \frac{1}{2}(600+600)\times 10^{-12}\times(100)^2 = 6\times 10^{-6}\,J$$

Now energy lost $= (12-6)\times 10^{-6}\,J = 6\times 10^{-6}\,J$ **(1)**

**17.** Names are

(i) X-rays

(ii) Ultraviolet rays

(iii) Infrared rays

(iv) Radio waves

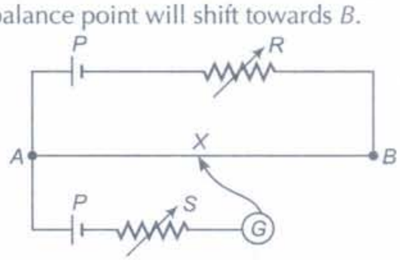
(v) Ultraviolet rays **(2)**

**18.** (i) Intensity of magnetisation is the magnetic moment per unit volume of specimen of material is larger in the ferromagnetic material to that of paramagnetic material.

(ii) There is a strong magnetic field inside the ferromagnetic material where as the field is reduced in diamagnetic materials by itself.

(iii) Succeptiblitiy is positive for ferromagnetic where as negative for diamagnetic substances. **(2)**

**19.** (i) When resistance *R* is increased, the current through potentiometer wire *AB* will decrease, so potential difference across *AX* will decrease, so balance point will shift towards *B*.

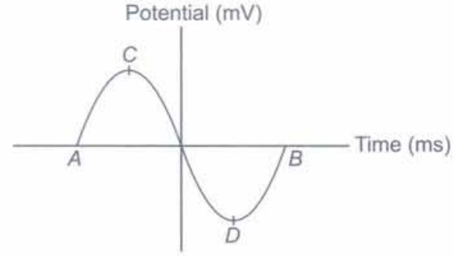



**(1)**

(ii) When resistance *S* is increased, there is no change in balance point, since at balance there is no current in secondary circuit. **(1)**

(iii) When cell *P* is repaced by a cell of lower emf than *Q*, the potential difference across *AB* will be lower than that of emf of *Q* so balance point will not be obtained. **(1)**

**20.** (i) The graph will be as shown below




As bar magnet *M* dropped so that it approaches the coil (with motion of it is vertical), the magnetic flux through the coil changes, an emf induced in coil which will oppose the motion of magnet towards the coil.

As the magnet is approaching the coil the flux linked through the coil gradually increases and hence the induced emf increases and reaches to its maximum value when magnet is fully inside the coil. **(1)**

Again magnet starts living the coil the rate of change of flux again induces an emf (opposite to primarily supposed emf) in coil. But right now the emf linked through the coil is decreases and hence magnitude of induced emf is decreases and goes to its minimum value. If we take one direction of emf as positive for increasing flux linkage through the coil then obviously the other direction of induced emf will be negative for decreasing flux linkage through the coil.

(ii) The negative peak of the graph is longer than the positive peak due the speed of falling the magnet.

Firstly, when magnet is approaches the coil, there is an extra force on the magnet in the direction opposite to its motion and hence acceleration due to this extra forces weaker the gravitation acceleration due to which the acceleration of the bar magnet is reduced which is the cause of shorter positive peak. **(1)**

While on the other hand when magnet leaving the coil the flux linked through coil decreases which exerts a downward force on the magnet and hence the gravitational acceleration is increase *i.e*, speed of magnet is increased with time which associates the larger rate of change of flux linked the coil. Due to this reason the negative peak of the curve is longer than positive one. **(1)**

**21.** Angular width of central maxima is given by

$$\theta = \frac{2\lambda}{a}$$

$$\Rightarrow \qquad \theta \propto \frac{1}{a}$$

On the basis of above equation

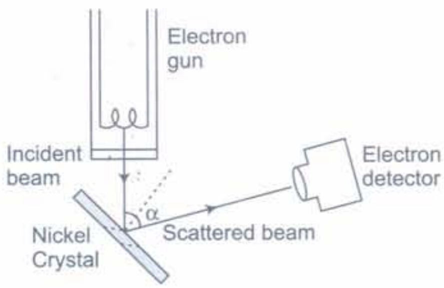
(i) On decreasing slit width, the angular width of central maxima increases. (1)

(ii) Angular width of central maxima will remain unchanged because it is independent of the distance between the slit and the screen. (1)

(iii) Width of central maxima decreases when light of smaller wavelengths are used. (1)

**22.** Davisson and Germer performed a diffraction experiment with electron beam in analogy with X-rays diffraction to observe the wave nature of matter.

**Apparatus** It consists of three parts




(1)

(i) **Electron Gun** It gives a fine beam of electrons. de-Broglie used electron beam of energy 54 eV. de-Broglie wavelength associated with this beam

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

Here $m$ = mass of electron $= 9.1 \times 10^{-31}$ kg

$E_K$ = Kinetic energy of electron = 54 eV

$$= 54 \times 1.6 \times 10^{-19} \text{ J} = 86.4 \times 10^{-19} \text{ J}$$

$$\lambda = \frac{6.6 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 86.4 \times 10^{-19}}}$$

$$= 1.66 \times 10^{-10} \text{ m} = 1.66 \text{ Å}$$ (1/2)

(ii) **Nickel Crystal** The electron beam was directed on nickel crystal against its (iii) face. The smallest separation between nickel atom is 0.914 Å. Nickel crystal behaves as difraction grating.(1/2)

(iii) **Electron Detector** It measures the intensity of electron beam diffracted from nickel crystal. It may be an ionisation chamber fitted with a sensitive galvanometer. The energy of electron beam, the angle of incidence of beam on nickel crystal and the position of detector can all be varied. (1/2)

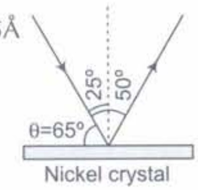
**Method** The crystal is rotated in small steps to change the angel ($\alpha$ say) between incidence and scattered directions and the corresponding intensity ($I$) of scattered beam is measured. The variation of the intensity ($I$) of the scattered electrons with the angle of scattering $\alpha$ is obtained for different accelerating voltages.

The experiment was performed by varying the accelerating voltage form 44 V to 68 V. It was noticed that a strong peak appeared in the intensity ($I$) of scattered electron for an accelerating voltage of 54V at a scattering angle $\alpha = 50°$.

$\therefore$ From Bragg's law

$$2d \sin\theta = n\lambda$$

Here $n = 1, d = 0.914$ Å, $\theta = 65$Å




$$\lambda = \frac{2d \sin\theta}{n}$$

$$= \frac{2 \times (0.914 \text{ Å}) \sin 65 \text{ Å}}{1}$$

$$= 2 \times 0.914 \times 0.9063 \text{ Å} = 1.65 \text{ Å}$$

The measured wavelength is in close agreement with the estimated de-Broglie wavelenth. Thus the wave nature of electron is verified. (1/2)

OR

Einstein's photoelectric equation

$$KE_{max} = h\nu - W_0 \quad \ldots(i)$$

where, $\nu$ = frequency of incident light beam

$W_0$ = work function of matel

$KE_{max}$ = maximum kinetic energy

$\because \quad W_0 = h\nu_0$

where, $\nu_0$ is threshold frequency.

$$\Rightarrow \quad KE_{max} = h\nu - h\nu_0 \quad (1)$$

$$KE_{max} = h(\nu - \nu_0) \quad \ldots(ii)$$

This equation is obtained by considering the particle nature of electromagnetic radiation.

Three salient features observed in photoelectric effect and their explanation on the basis of Einstein's photoelectric equation is given below

(a) **Threshold frequency** For $KE_{max} \geq 0$,

$$\Rightarrow \quad \nu \geq \nu_0 \quad \text{[From Eq. (ii)]}$$

*i.e.,* the phenomenon of photoelectric takes place when incident frequency is greater or equal to minimum frequency (threshold frequency) $\nu_0$ fixed for given metal. (1/2)

(b) **$KE_{max}$ of photoelectron** When incident frequency is greater than threshold frequency, then $KE_{max}$ of photoelectron is directly proportional to $(\nu - \nu_0)$ as

$$KE_{max} = h(\nu - \nu_0) \quad \text{[From Eq. (ii)]}$$

$$\Rightarrow \quad KE_{max} \propto (\nu - \nu_0) \quad (1/2)$$

(c) **Effect of intensity of incident light** The number of photon incident per unit time per unit area increases with the increase of intensity of incident light. More number of photons facilitate ejection of more number of photoelectrons from metal surface leads to further increase of photocurrent till its saturation value. **(1)**

**23.** As we know that

$$\text{Activity, } \frac{dN}{dt} = -\lambda N$$

Differentiating it with respect to time we get,

$$\frac{d\left(\frac{dN}{dt}\right)}{dt} = \frac{d(-\lambda N)}{dt}$$

$$= -\lambda \frac{dN}{dt} \quad \textbf{(1)}$$

$$\Rightarrow \quad \frac{d^2N}{dt^2} = -\lambda(-\lambda N) \quad \left(\text{As } \frac{dN}{dt} = -\lambda N\right)$$

$$= \lambda^2 N \quad \text{...(i)}$$

Also, $\lambda = \frac{0.693}{t_{1/2}}$ **(1)**

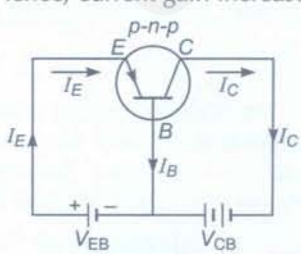
Put the value of $\lambda$ in Eq. (i), we get

$$\frac{d^2N}{dt^2} = \left(\frac{0.693}{t_{1/2}}\right)^2 N$$

$$= \frac{(0.693)^2 N}{(t_{1/2})^2}$$

$$\Rightarrow \quad \frac{d^2N}{dt^2} \propto \frac{1}{(t_{1/2})^2} \quad [\text{As } (0.693)^2 \times N = \text{constant}]$$ **(1)**

**24.** The thin and lightly doped base region offers lesser number of majority charge carrier in base region which reduces the possibility of combination of electron hole pair in base region and hence, reducing the base current. Also, this leads to increase collector current. Hence, current gain increases in transistor.

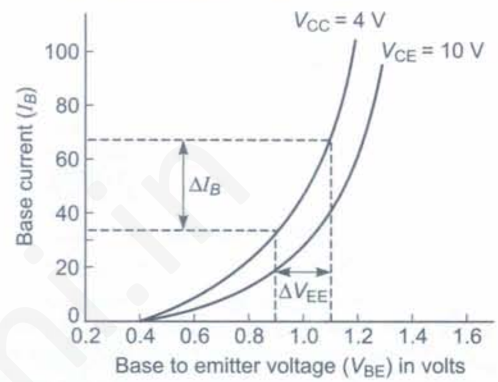



**(1)**

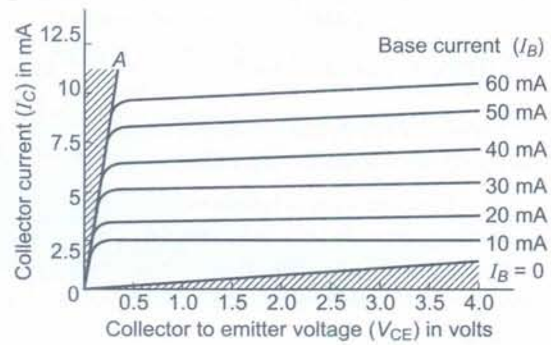
The forward bias of emitter-base circuit exert force on holes towards collector *via* base region. Since, the base region is very thin and lightly doped, therefore a nearly 5% of holes combines with the electrons in base region and remains nearly 95% holes enters into the collector region under the influence of $V_{EB}$. The deficiency of these 5% electrons in base region is compensated from negative terminal of battery and set-up small base current $I_B$. The excess of holes (95%) in collector region get combined with the electron drawn from the negative terminal of $V_{CB}$ and get annihilated. Consequency corresponding strong collector current $I_C$ flows from collector to $V_{CB}$. The 100% deficiency of holes in emitter region is compensated with the breading of covalent bond in emitter region and additional electrons flows from emitter region to positive terminal of $V_{EB}$ and corresponding emitter current $I_E$ flows from battery to emitter. Now, by Kirchhoff's junctions rule,

$$I_E = I_C + I_B \quad \textbf{(1)}$$

Input characteristic curve




Output characteristic curve




**Output characteristic curve and current gain** The current gain $\beta$ can be obtained by draw a line parallel to $I_C$-axis at given $V_{CE}$.

Finding the change in collector current ($\Delta I_C$) corresponding to two given values of $I_B$ hence, finding $\Delta I_B$.

Thus, $\beta = \left(\frac{\Delta I_C}{\Delta I_B}\right)_{V_{CE} = \text{constant}}$ **(1)**

**25.** As the magnetic force acting on the particle in the uniform magnetic field is given by

$$F = qvB\sin\theta = qvB \quad (\text{As, } \theta = 90°)$$

The particle will follow the circular path in the magnetic field as

$$\frac{mv^2}{r} = qvB$$

$\therefore \quad v = \frac{qBr}{m}$ **(1)**

Now

(i) Time period of the revolution $= \frac{2\pi r}{v}$

$\Rightarrow \quad T = \frac{2\pi rm}{qBr} = \frac{2\pi m}{qB}$ **(1)**

(ii) As $mv = qBr = p$

$\therefore$ Kinetic energy $= \frac{p^2}{2m}$

$$KE = \frac{q^2B^2r^2}{2m}$$ **(1)**

**26.** (i) Teacher is the one who guides us for wrong and right, who helps us and makes us aware at every step of our life.

Whenever a student asks anything from his ideal teacher. Teacher should explain the things in detail to the student for his perfection and betterment.

Teacher should guide him for the steps he must take to fulfil his dream.

The steps must be explained that the student after completing his senior secondary school in science with maths as stream, should go for his graduation in astronomy and give his best shot at every step to achieve his goal.

But for now, student should focus on his primary studies as this decision is to be taken later on. More concentration and devotion is then required from now only. **(2)**

(ii) Let $x$ be the size of linear object that can be resolved

$\therefore$ Limit of resolution, $Q = \frac{x}{D} = \frac{\lambda}{a}$

Given, $\lambda = 5 \times 10^{-7}$ m

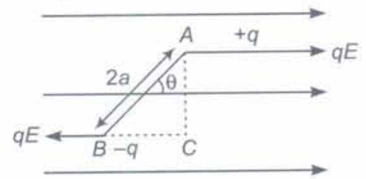
$a = 5 \times 10^{-3}$ m

and $D = 5 \times 10^{5}$ m

$\Rightarrow \quad x = \frac{\lambda}{a} \times D = \frac{5 \times 10^{-7} \times 5 \times 10^{5}}{5 \times 10^{-3}}$

$\Rightarrow \quad x = 50$ m **(2)**

**27.** Consider the electric dipole $AB$ in the electric field as shown in figure.




Here, electric force on $+q$ charge,

$F_1 = qE$ (along **E**) **(1)**

and the electric force on $-q$ charge

$F_2 = -qE$ (opposite to **E**) **(1)**

These two forces forms a couple of forces whose torque will be

$\tau =$ force $\times$ perpendicular distance between the forces

$= qE \times AC = qE \times 2a\sin\theta$

But,

$q \times 2a = p =$ electric dipole moment

$\therefore \quad \tau = pE\sin\theta = \mathbf{p} \times \mathbf{E}$ **(1)**

Now

(i) The torque will be maximum when $\theta = 90°$

*i.e.,* $\tau = pE$

(ii) The torque will be half the maximum value when $\theta = 30°$

*i.e.,* $\tau = \frac{1}{2}pE$

and **(1)**

(iii) The torque will be zero when electric dipole, $p$ is along the direction of $E$ *i.e.,* $\theta = 0$

$\Rightarrow \quad \tau = 0$ **(1)**

OR

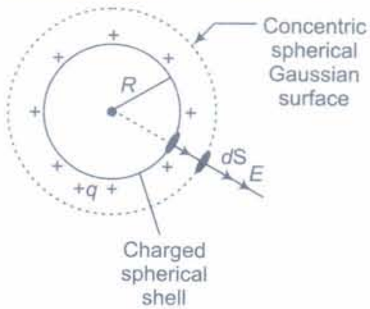
Gauss's law states that the total electric flux through a closed surface is equal to $\frac{1}{\varepsilon_0}$ times the magnitude of the charge enclosed by it.

$$\phi = \frac{q}{\varepsilon_0}$$ **(1)**

Here, $\varepsilon_0$ is the absolute permittivity of the force space and $q$ is the total charge enclosed.

Also, $\phi = \oint_S \mathbf{E} \cdot d\mathbf{s} = \frac{q}{\varepsilon_0}$ **(1)**

where, **E** is the electric field at the area element $ds$.




**(1/2)**

Let us consider charge $+q$ is uniformly distributed over a spherical shell of radius $R$. Let $E$ is to be obtained at $P$ lies outside of spherical shell.

$\because$ **E** at any point is radially outward (if charge $q$ is positive) and has same magnitude at all points which lies at the same distance ($r$) from centre of spherical shell such that $r > R$. Therefore, Gaussian surface is concentric sphere of radius $r$ such that $r > R$. **(1/2)**

$\because$ Gaussian surface enclosed charge $q$ inside it.

By Gauss's theorem

$$\oint \mathbf{E}.\mathbf{ds} = \frac{q}{\varepsilon_0}$$

$$\oint E.ds\cos 0° = \frac{q}{\varepsilon_0}$$

[$\because$ $E$ and $ds$ are along the same direction]

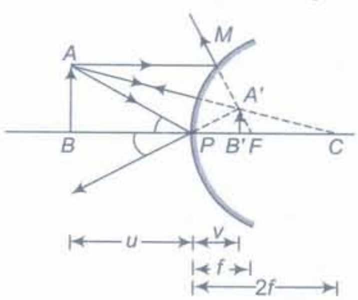
$$E\oint ds = \frac{q}{\varepsilon_0}$$

[$\because$ Magnitude of E is same at every point on Gaussian surface]

$$\Rightarrow \quad E \times 4\pi r^2 = \frac{q}{\varepsilon_0}$$

$$\therefore \quad E = \frac{1}{4\pi\varepsilon_0}.\frac{q}{r^2}$$

**28.** (i) Let convex mirror form virtual, erect diminished image $A'B'$ on the other side of mirror of an object $AB$ as shown in below figure.




Let $\quad PC = +2f = R, PB' = +v, PB = -u$

$\because \quad \Delta A'B'C$ is similar to $\Delta ABC$

$$\Rightarrow \quad \frac{A'B'}{AB} = \frac{CB'}{CB}$$

$$= \frac{PC - PB'}{PC + PB} = \frac{R - v}{R - u} \quad \text{...(i)}$$

Also, $\quad \Delta A'B'P \sim \Delta ABP$

$$\Rightarrow \quad \frac{A'B'}{AB} = \frac{AB'}{PB} = \frac{v}{-u} \quad \text{...(ii)}$$

From Eqs. (i) and (ii), we get

$$\frac{R - v}{R - u} = -\frac{v}{u}$$

$$uR - uv = -vR + uv$$

$$2uv = uR + vR \quad \textbf{(1)}$$

Dividing by $uvR$, we get

$$\frac{2}{R} = \frac{1}{v} + \frac{1}{u}$$

$$\because \quad R = 2f$$

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} \quad \textbf{(1)}$$

This is required expression of mirror formula.

And, the lens formula is

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

(ii) Distance of object from lens $u = -10$ cm

$$f = 40 \text{ cm}$$

Using lens formula,

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} \quad \textbf{(1)}$$

$$\frac{1}{40} = \frac{1}{v} - \frac{1}{10}$$

$$\frac{1}{v} = \frac{1}{40} + \frac{1}{10}$$

$$\frac{1}{v} = \frac{1+4}{40} = \frac{5}{40}$$

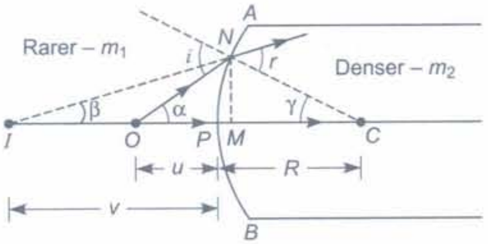
$$v = 8 \text{ cm}$$

$$m = -\frac{v}{u} = \frac{8}{10} = \frac{2}{5} < 1 \quad \textbf{(1)}$$

When the needle is moved further away from the convex mirror, its image moves further behind the convex mirror towards the focus and its size goes on increasing. When it is far off, it appears almost as a point image at the focus. **(1)**

OR

Let an object $O$ is placed at a distance $u$ from convex spherical refracting surface whose virtual image forms at $I$ at a distance $v$ from surface. Let $R$ is the radius of curvature of surface. **(1)**




(1)

In $\Delta ONC$, $i = \alpha + \gamma$ ...(i)

In $\Delta INC$, $r = \beta + \gamma$ ...(ii)

Also, for small angles $\alpha, \beta$ and $\gamma$

$$\alpha \simeq \tan\alpha = \frac{NM}{OM} \simeq \frac{NM}{PO} = \frac{h}{-u}$$

(Minimum close to $P$)

where, $h = NM$

$$\beta \simeq \tan\beta = \frac{NM}{IM} \simeq \frac{NM}{PI} = \frac{h}{-v} \quad ...(iii)$$

Also, $\gamma \simeq \tan\gamma = \frac{NM}{MC} \simeq \frac{NM}{PC} = \frac{h}{+R}$ (1)

But by Snell's law

$$\frac{\sin i}{\sin r} = \frac{\mu_2}{\mu_1}$$

where, $\mu_2, \mu_1$ are the refractive indices of denser medium and rarer medium respectively.

For small angle $i$ and $r$

$$\sin i \approx i, \ \sin r \approx r$$

$$\Rightarrow \quad \frac{i}{r} = \frac{\mu_2}{\mu_1}$$

$$\Rightarrow \quad \mu_1 i = \mu_2 r$$

$$\mu_1(\alpha + \gamma) = \mu_2(\beta + \gamma) \quad \text{[From Eqs. (i) and (ii)]}$$

$$\mu_1\alpha - \mu_2\beta = (\mu_2 - \mu_1)\gamma \quad (1)$$

$$\Rightarrow \mu_1\left(\frac{h}{-u}\right) - \mu_2\left(\frac{h}{-v}\right) = \left(\frac{h}{+R}\right)(\mu_2 - \mu_1) \quad \text{[From Eq. (iii)]}$$

$$\Rightarrow \quad \frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$$

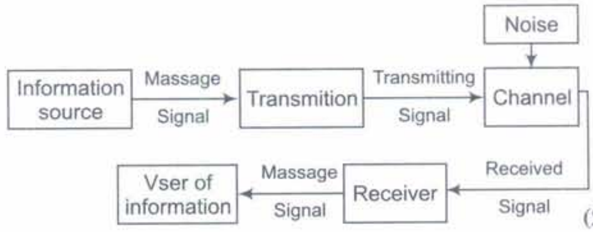
This is the required expression. (1)

**29.** Space wave communication is known as LOS communication. The radio wave transmitted by antenna directly reaches the receiving antenna by travelling along a straight line. TV waves (50 MHz-200 MHz) propagate through space wave propagate.

Range of frequency suitable for space wave propagation is 100MHz to 220 MHz. (2)

Examples of communication system which use space wave mode are television channel, UHF, VHF etc(1)

Diagram of communication system




(2)

OR

The radio wave transmitted by antenna directly reaches the receiving antenna by travelling along a straight line. TV wave propagates through the space wave propagation. The communication system uses the space waves are TV channel VHF, UHF. (1)

The typical uses of space communication are Radar communication, air navigation, FM and SW transmission etc.

Now, as maximum line of sight distance is given by

$$d_M = \sqrt{2Rh_T} + \sqrt{2Rh_R} \quad ...(i)$$

(1)

In the question given $h_T + h_R = h$

We have to find out the condition when $d_M$ will be maximum with respect to the height $h$. (1)

By differentiating Eq. (i) with respect to $h$, we get

$$\frac{d(d_M)}{dh} = \sqrt{2R}\left(\frac{1}{2\sqrt{h_T}} + \frac{1}{2\sqrt{h_R}}\right)$$

For maximum $d_M$,

$$\frac{d(dM)}{dh} = 0$$

$$\Rightarrow \quad \sqrt{2R}\left(\frac{1}{2\sqrt{h_T}} + \frac{1}{2\sqrt{h_R}}\right) = 0 \quad (1)$$

$\Rightarrow$ $h_T = h_R$

Now if $h_T + h_R = h$ then,

either $h_T + h_T = h$

or $h_R + h_R = h$

Either, $h_T = \frac{h}{2}$

or $h_R = \frac{h}{2}$. (1)