Solved Paper 2019
Physics
Class-XII

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

General Instructions :

(i) *All questions are compulsory. There are **27** questions in all.*
(ii) *This question paper has **four** sections : Section **A**, Section **B**, Section **C** and Section **D**.*
(iii) *Section **A** contains **five** questions of one mark each, Section **B** contains **seven** questions of **two** marks each, Section **C** contains **twelve** questions of **three** marks each, Section **D** contains **three** questions of **five** marks each.*
(iv) *There is no overall choice. However, an internal choice (s) has been provided in **two** questions of **one** mark, **two** questions of **two** marks, **four** questions of **three** marks and **three** questions of **five** marks weightage. You have to attempt only **one** of the choices in such questions.*
(v) *You may use the following values of physical constants wherever necessary :*

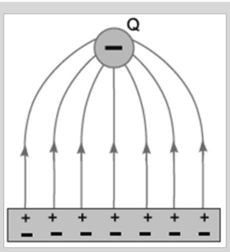
$c = 3 \times 10^8$ m/s
$h = 6.63 \times 10^{-34}$ Js
$e = 1.6 \times 10^{-19}$ C
$\mu_0 = 4\pi \times 10^{-7}$ TmA^{-1}
$\varepsilon_0 = 8.854 \times 10^{-12}$ C^{2}N^{-1}m^{-2}
$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ Nm^{2}C^{-2}
Mass of electron (m_e) $= 9.1 \times 10^{-31}$ kg
Mass of neutron $= 1.675 \times 10^{-27}$ kg
Mass of proton $= 1.673 \times 10^{-27}$ kg
Avogadro's number $= 6.023 \times 10^{23}$ per gram mole
Boltzmann constant $= 1.38 \times 10^{-23}$ JK^{-1}

Delhi Set I **Code No. 55/1/1**

SECTION -A

1. Draw the pattern of electric field lines, when a point charge – *Q* is kept near an uncharged conducting plate. 1

Ans.



1

[**Note: (i)** Deduct ½ mark, if arrows are not shown. **(ii)** do not deduct any mark, if charges on the plates are not shown]

[CBSE Marking Scheme, 2019]

2. How does the mobility of electrons in a conductor change, if the potential difference applied across the conductor is doubled, keeping the length and temperature of the conductor constant? 1

Ans. Halved **1**

[CBSE Marking Scheme, 2019]

Answer:

Electron mobility is given by

$$u = \frac{v_d}{E} = \frac{v_d}{V/l}$$

Here E = magnitude of electric field applied

v_d = drift velocity, V = p.d., l = length

So, $u \propto \frac{1}{V}$ **1**

Hence, for the constant length and temperature of the conductor, if the potential difference is doubled, the mobility will be halved.

3. Define the term "threshold frequency" in the context of photoelectric emission. 1

OR

Define the term "Intensity" in photon picture of electromagnetic radiation. **1**

Ans. Threshold frequency equals the minimum frequency of incident radiation (light) that can cause photoemission from a given, photosensitive surface. **[Alternatively]** The frequency below which the incident radiations cannot cause the photoemission from photosensitive surface.

[CBSE Marking Scheme, 2019] 1

OR

Intensity of radiation is proportional to (equal to) the number of energy quanta (photons) per unit area per unit time. **1**

[CBSE Marking Scheme, 2019]

4. What is the speed of light in a denser medium of polarising angle 30°? **1**

Ans. $d\mu_r = \tan 30° = \frac{1}{\sqrt{3}}$ ½

(where $d\mu_r$ is the refractive index of rarer medium w.r.t. denser medium)

$\therefore \mu_d = \sqrt{3}$

$$v = \frac{c}{\mu} = \frac{3 \times 10^8}{\sqrt{3}} = \sqrt{3} \times 10^8 \text{ m/s}$$ ½

[**Note** : Also accept if a student solves it as follows]

$\mu = \tan i_p$

$\mu = \tan 30° = \frac{1}{\sqrt{3}}$ ½

$$\therefore v = \frac{3 \times 10^8}{\frac{1}{\sqrt{3}}} = 3\sqrt{3} \times 10^8 \text{ m/s}$$ ½

(**Note :** Award this one mark if a student just writes the formula but does not solve it.)

[CBSE Marking Scheme, 2019]

***5. In sky wave mode of propagation why is the frequency range of transmitting signals restricted to less than 30 MHz?** **1**

OR

*** On what factors does the range of coverage in ground wave propagation depend?** **1**

SECTION -B

6. Two bulbs are rated (P_1, V) and (P_2, V). If they are connected (i) in series and (ii) in parallel across a supply V, find the power dissipated in the two combinations in terms of P_1 and P_2. **2**

Ans. Calculation of Power dissipation in two combinations **1+1**

$$R_1 = \frac{V^2}{P_1}, R_2 = \frac{V^2}{P_2},$$

$$P_s = \frac{V^2}{R_s} = \frac{P_1 P_2}{P_1 + P_2}$$

$$\frac{1}{P_s} = \frac{1}{P_1} + \frac{1}{P_2}$$

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{P_1 + P_2}{V^2}$$ ½

$$\therefore P_p = \frac{V^2}{R_p} = P_1 + P_2$$ ½

[CBSE Marking Scheme, 2019]

7. Calculate the radius of curvature of a equi-concave lens of refractive index 1.5, when it is kept in a medium of refractive index 1.4, to have a power of –5D? **2**

OR

An equilateral glass prism has a refractive index 1.6 in air. Calculate the angle of the minimum deviation of the prism, when kept in a medium of refractive index $\frac{4\sqrt{2}}{5}$.

Ans. Calculation of focal length ½

Lens maker's formula ½

Calculation of radius of curvature **1**

$$f = \frac{1}{P} = \frac{1}{-5} \text{ m} = -\frac{100}{5} \text{ cm} = -20 \text{ cm}$$ ½

$$\frac{1}{f} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$ ½

$\mu_2 = 1.5, \mu_1 = 1.4, R_1 = -R, R_2 = R$

$$\frac{1}{-20} = \left(\frac{1.5}{1.4} - 1\right)\left(-\frac{1}{R} - \frac{1}{R}\right)$$

$$\frac{1}{-20} = \left(\frac{0.1}{1.4}\right)\left(-\frac{2}{R}\right)$$ ½

$$R = \frac{20}{7} \text{ cm } (= 2.86 \text{ cm})$$ ½

[CBSE Marking Scheme, 2019]

OR

Formula ½

Substitution and calculation **1½**

$$\mu = \frac{\sin\frac{(A + \delta_m)}{2}}{\sin\frac{A}{2}}$$

$$\mu = \frac{\mu_1}{\mu_2} = \frac{1.6}{\frac{4}{5}\sqrt{2}} = \frac{8}{4\sqrt{2}} = \sqrt{2}$$

* *Out of Syllabus*

$$\mu = \frac{\mu_1}{\mu_2} = \frac{1.6}{\frac{4}{5}\sqrt{2}} = \frac{8}{4\sqrt{2}} = \sqrt{2}$$

$$\sqrt{2} = \frac{\sin\left(\frac{60° + \delta_m}{2}\right)}{\sin\frac{60°}{2}} = \frac{\sin\left(\frac{60° + \delta_m}{2}\right)}{\sin 30°} \qquad ½$$

$$\therefore \quad \sin\left(\frac{60 + \delta_m}{2}\right) = \sqrt{2}.\frac{1}{2} = \frac{1}{\sqrt{2}} = \sin 45°$$

$$\therefore \quad \frac{60 + \delta_m}{2} = 45°$$

$$\therefore \quad \delta_m = 30° \qquad ½$$

[CBSE Marking Scheme, 2019]

8. **An α-particle and a proton of the same kinetic energy are in turn allowed to pass through a magnetic field $\vec{B}$, acting normal to the direction of motion of the particles. Calculate the ratio of radii of the circular paths described by them. 2**

Ans. Formula ½

Calculation of ratio of radii 1½

$$\text{radius } r = \frac{mv}{qB} = \frac{\sqrt{2mk}}{qB}$$

$K_a = K_{proton}$ ½

$M_a = 4m_p$ ½

$q_a = 2q_p$

$$\frac{r_\alpha}{r_p} = \frac{\frac{\sqrt{2m_\alpha K}}{q_\alpha B}}{\frac{\sqrt{2m_p K}}{q_p B}} \qquad ½$$

$$= \sqrt{\frac{m_\alpha}{m_p}} \times \frac{q_p}{q_\alpha}$$

$$= \sqrt{4} \times \frac{1}{2} = 1 \qquad ½$$

[CBSE Marking Scheme, 2019]

9. **State Bohr's quantization condition of angular momentum. Calculate the shortest wavelength of the Bracket series and state to which part of the electromagnetic spectrum does it belong. 2**

OR

Calculate the orbital period of the electron in the first excited state of hydrogen atom. 2

Ans. Statement of Bohr's quantization condition ½

Calculation of shortest wavelength 1

Identification of part of electromagnetic spectrum ½

Electron revolves around the nucleus only in those orbits for which the angular momentum is some integral of $h/2\pi$. (where h is Planck's constant) ½

Also give full credit if a student write mathematically $mvr = \frac{nh}{2\pi}$

$$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

For Brackett Series,

Shortest wavelength is for the transition of electrons from $n_i = \infty$ to $n_f = 4$

$$\frac{1}{\lambda} = R\left(\frac{1}{4^2}\right) = \frac{R}{16}$$

$$\lambda = \frac{16}{R}\text{m}$$

= 1458.5 nm on substitution of value of R1

[**Note :** Don't deduct any mark for this part, when a student does not substitute the value of R, to calculate the numerical value of λ]

Infrared region. ½

[CBSE Marking Scheme, 2019]

OR

Statement of the formula for r_n ½

Statement of the formula for v_n ½

Obtaining formula for T_n ½

Getting expression for T_2 (n = 2) ½

$$\text{Radius, } r_n = \frac{h^2\varepsilon_0}{\pi me^2}n^2$$

$$\text{velocity, } v_n = \frac{2\pi e^2}{4\pi\varepsilon_0 h}\frac{1}{n}$$

$$\text{Time period, } T_n = \frac{2\pi r_n}{v_n} = \frac{4\varepsilon_0^2 h^3 n^3}{me^4} \qquad ½$$

For first excited state of hydrogen atom n = 2 ½

$$T_2 = \frac{32\,\varepsilon_0^2 h^3}{me^4} \qquad ½$$

On calculation we get $T_2 \approx 1.22 \times 10^{-15}$ s.

Note : Do not deduct the last ½ mark if a student does not calculate the numerical value of [T_2]

Alternatively,

$$r_n = (0.53n^2)\ \text{Å} = 0.53 \times 10^{-10} n^2$$

$$v_n = \left(\frac{c}{137n}\right)$$

$$T_n = \frac{2\pi(0.53)}{\left(\frac{c}{137n}\right)} \times 10^{-10} n^2 \qquad ½$$

$$= \frac{2\pi(0.53)}{c} \times 10^{-10} n^3 \times 137s$$

$$= \frac{2 \times 3.14 \times 0.53 \times 10^{-10} \times 8 \times 137}{3 \times 10^8}s \qquad ½$$

$$= 1215.97 \times 10^{-18} = (1.22 \times 10^{-15})s$$

Alternatively,

If the student writes directly $T_n \propto n^3$

T_2 = 8 times of orbital period of the electron in the ground state (award one mark only)

[CBSE Marking Scheme, 2019]

*** 10. Why a signal transmitted from a TV tower cannot be received beyond a certain distance? Write the expression for the optimum separation between the receiving and the transmitting antenna. 2**

11. Why is wave theory of electromagnetic radiation not able to explain photoelectric effect? How does photon picture resolve this problem? 2

Ans. Reason for inability of E.M. theory 1

Resolution through photon picture 1

The explanation based on e.m. theory does not agree with the experimental observations (instantaneous nature , max K.E. of emitted photoelectron is independent of intensity, existence of threshold frequency) on the photoelectric effect. 1

[**Note :** Do not deduct any mark if the student does not mention the relevant experimental observation or mentions any one or any two of these observations].

The photon picture resolves this problem by saying that light, in interaction with matter behaves as if it is made of quanta or packets of energy, each of energy hν. This picture enables us to get a correct explanation of all the observed experimental features of photoelectric effect. 1

[**Note** : Award the first mark if the student just writes "As per E.M. theory the free electrons at the surface of the metal absorb the radiant energy continuously, this leads us to conclusions which do not match with the experimental observations"].

Also award the second mark if the student just writes "The photon picture give us the Einstein photoelectric equation

$$K_{max} (= eV_0) = h\nu - \phi_0$$

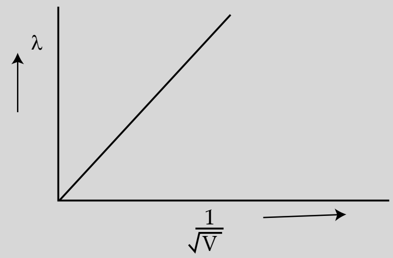
which provides a correct explanation of the observed features of the photoelectric effect.

[CBSE Marking Scheme, 2019]

12. Plot a graph showing variation of de Broglie wavelength (λ) associated with a charged particle of mass *m*, versus $\frac{1}{\sqrt{V}}$, where *V* is the potential difference through which the particle is accelerated. How does this graph give us the information regarding the magnitude of the charge of the particles? 2

Ans. Plot of the graph showing the variation of λ Vs $\frac{1}{\sqrt{V}}$ 1

Information regarding magnitude of charge 1



1

$$\because \quad \lambda = \frac{h}{\sqrt{2mqV}}$$

$$\frac{\lambda}{\left(\frac{1}{\sqrt{V}}\right)} = \frac{h}{\sqrt{2mq}} = \text{slope}$$

$$q = \frac{h^2}{2m(\text{slope})^2}$$

½

[CBSE Marking Scheme, 2019]

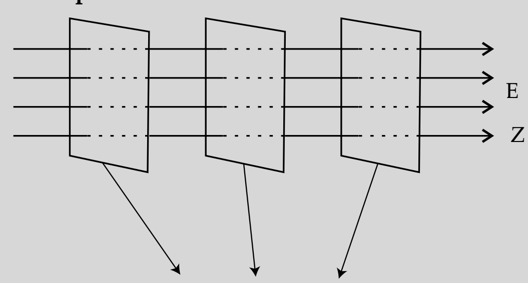
SECTION -C

13. (a) Draw the equipotential surfaces corresponding to a uniform electric field in the Z-direction.

(b) Derive an expression for the electric potential at any point along the axial line of an electric dipole. 3

Ans. (a) Drawing of equipotential surfaces 1

(b) Derivation of the expression of electric potential 2



Equipotential surfaces

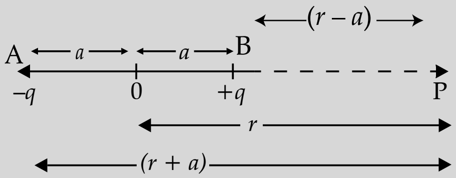
1

[**Note :** Award ½ mark if the student just write : The equipotential surfaces are the equidistant planes perpendicular to the Z-axis and does not draw them or "The equipotential surfaces are equidistant planes parallel to the X-Y Plane"].

[**Note :** In this part the Hindi version requires the student to draw equipotential surfaces for a uniform magnetic field].

"Award this 1 mark if the student just writes that these cannot be drawn."

* *Out of Syllabus*

(b) 

½

Potential at point P

$V_p = V_{-q} + V_{+q}$ ½

$$= \frac{1}{4\pi\varepsilon_0}\frac{-q}{(r+a)} + \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-a)}$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{(r-a)} - \frac{1}{(r+a)}\right]$$

$$= \frac{q}{4\pi\varepsilon_0}\left[\frac{r+a-r+a}{(r-a)(r+a)}\right]$$

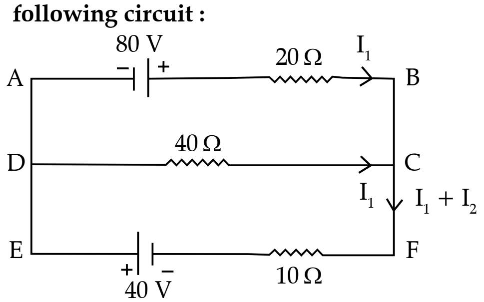
$$= \frac{q}{4\pi\varepsilon_0} \times \frac{2a}{(r^2-a^2)} = \frac{q \times 2a}{4\pi\varepsilon_0(r^2-a^2)}$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{p}{(r^2-a^2)}$$ ½

where, p is the dipole moment.

[CBSE Marking Scheme, 2019]

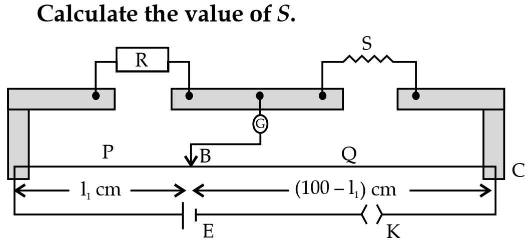
14. Using Kirchhoff's rules, calculate the current through the 40 Ω and 20 Ω resistors in the following circuit : 3



OR

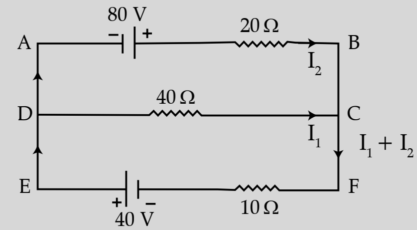
What is end error in a metre bridge? How is it overcome? The resistances in the two arms of the metre bridge are R = 5 Ω and S respectively.

When the resistance S is shunted with an equal resistance, the new balance length found to be 1.5 l_1 where l_1 is the initial balancing length. Calculate the value of S.



Ans. (a) Writing two loop equations 1 + 1

(b) Calculation of currents through 40 Ω and 20 Ω resistors 1



In loop ABCDA

$+80 - 20I_2 + 40I_1 = 0$

$4 = I_2 - 2I_1$ **1**

In loop FCDEF

$-40I_1 - 10(I_1 + I_2) + 40 = 0$

$-50I_1 - 10I_2 + 40 = 0$

$5I_1 + I_2 = 4$ **1**

Solving these two equations

$I_1 = 0$ A ½

$I_2 = 4$ A ½

[CBSE Marking Scheme, 2019]

OR

End error, overcoming ½

Formula for metre bridge ½

Calculation of value of S **2**

The end error, in a metre bridge, is the error arising due to

(i) Ends of the wire not coinciding with the 0 cm / 100 cm marks on the metre scale. ½

(ii) Presence of contact resistance at the joints of the meter bridge wire with the metallic strips.

It can be reduced/overcome by finding balance length with two interchanged positions of R and S and taking the average value of 'S' from two readings. ½

(**Note:** Award this ½ make even if student just writes only the point (i) or point (ii) given above.)

For a metre bridge

$$\frac{R}{S} = \frac{l}{100-l}$$ ½

For the two given conditions

$$\frac{5}{S} = \frac{l_1}{100-l_1}$$

$$\frac{5}{S/2} = \frac{1.5l_1}{100-1.5l_1}$$ ½

Dividing the two equations

$$2 = \frac{1.5l_1}{(100-1.5l_1)} \times \frac{(100-l_1)}{l_1}$$

$$200 - 3l_1 = 150 - 1.5l_1$$

$$l_1 = \frac{100}{3} \text{ cm}$$

Putting the value of l_1 in any one of the two given conditions.

$S = 10\,\Omega$ ½

[CBSE Marking Scheme, 2019]

15. (a) Identify the part of electromagnetic spectrum used in (i) radar and (ii) eye surgery. Write their frequency range.

(b) Prove that the average energy density of the oscillating electric field is equal to that of the oscillating magnetic field. 3

Ans. (a) Identification ½ + ½

Frequency range ½ + ½

(b) Proof

Microwaves: Frequency range ($\sim 10^{10}$ to 10^{12} Hz) ½ + ½

Ultraviolet rays: Frequency range ($\sim 10^{15}$ to 10^{17} Hz) ½ + ½

[**Note:** Award $\left(\frac{1}{2}+\frac{1}{2}\right)$ marks for frequency ranges even if the student just writes the correct order of magnitude for them].

(b) Average energy density of the electric field

$$= \frac{1}{2}\varepsilon_0 E^2$$

$$= \frac{1}{2}\varepsilon_0 (cB)^2$$

$$= \frac{1}{2}\varepsilon_0 \frac{1}{\mu_0 \varepsilon_0} B^2$$

$$= \frac{1}{2}\frac{B^2}{\mu_0}$$ **1**

= Average energy density of the magnetic field.

[**Note:** Award 1 mark for this part if the student just writes the expressions for the average energy density of the electric and magnetic fields].

[CBSE Marking Scheme, 2019]

16. Define the term wavefront. Using Huygen's wave theory, verify the law of reflection. 3

OR

Define the term, "refractive index" of a medium. Verify Snell's law of refraction when a plane wavefront is propagating from a denser to a rarer medium.

Ans. Definition of the wavefront **1**

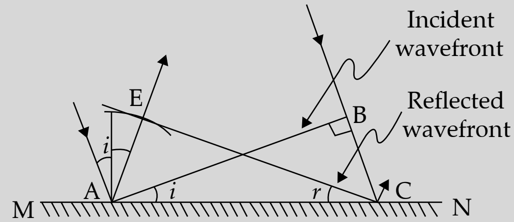
Verification of the law of Reflection **2**

The wave front is defined as a surface of constant phase **1**

Alternatively:

The wave front is a locus of points which oscillate in phase.

Consider a plane wave AB incident at an angle 'I' on a reflecting surface MN



1

let t = time taken by the wave front to advance from B to C.

$\therefore$ BC = vt

Let CE represent the tangent plane drawn from the point C to the sphere of radius 'vt' having A as its center.

then AE = BC = vt ½

it follows that

$$\Delta EAC \cong \Delta BAC$$

Hence $\angle i = \angle r$ ½

$\therefore$ Angle of incidence = angle of reflection

[CBSE Marking Scheme, 2019]

OR

Definition of the refractive index **1**

Verification of laws of refraction **2**

The refractive index of medium 2, w.r.t. medium 1 equals the ratio of the sine of angle of incidence (in medium 1) to the sine of angle of refraction (in medium 2). **1**

Alternatively,

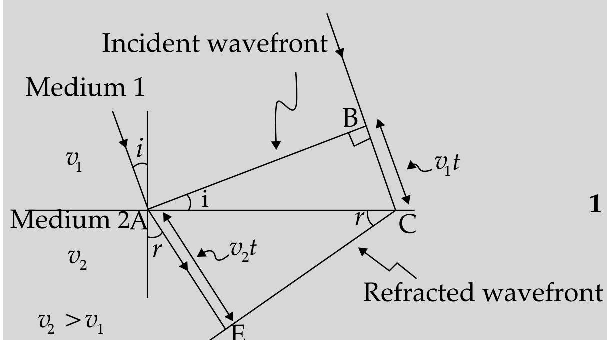
Refractive index of medium 2 w.r.t. medium **1**

$$n_{21} = \frac{\sin i}{\sin r}$$

Alternatively,

Refractive index of medium 2 w.r.t. medium **1**

$$n_{21} = \frac{\text{velocity of light in medium 1}}{\text{velocity of light in medium 2}}$$



1

The figure drawn here shows the refracted wave front corresponding to the given incident wave front.

It is seen that

$$\sin i = \frac{BC}{AC} = \frac{v_1 t}{AC}$$ ½

$$\sin r = \frac{AE}{AC} = \frac{v_2 t}{AC}$$

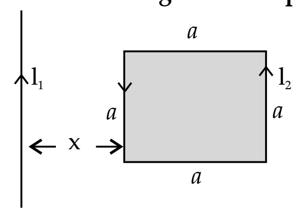
$$\therefore \quad \frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \mu_{21}$$ ½

This is Snell's law of refraction.

[CBSE Marking Scheme, 2019]

17. (a) Define mutual inductance and write its S.I. unit.

(b) A square loop of side 'a' carrying a current I_2 is kept at distance x from an infinitely long straight wire carrying a current I_1 as shown in the figure. Obtain the expression for the resultant force acting on the loop. **3**



Ans.(a) Definition of mutual inductance and S.I. unit **1+½**

(b) Obtaining the expression for resultant force on the loop **1½**

(a) Mutual inductance equals the magnetic flux associated with a coil when unit current flows in its neighbouring coil.

Alternatively,

Mutual inductance equals the induced emf in a coil when the rate of change of current in its neighbouring coil is one ampere/ second. **1**

S.I unit: henry (H) or weber/ampere (or any other correct SI unit) ½

(b) Force per unit length between two parallel straight conductors

$$F = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{d}$$

Force on the part of the loop which is parallel to infinite straight wire and at a distance x from it.

$$F_1 = \frac{\mu_0}{2\pi}\frac{I_1I_2a}{x}$$

(away from the infinite straight wire)½

Force on the part of the loop which is at a distance $(x + a)$ from it

$$F_2 = \frac{\mu_0}{2\pi}\frac{I_1I_2a}{(x+a)}$$

(towards the infinite straight wire) ½

Net force $F = F_1 - F_2$

$$F = \frac{\mu_0}{2\pi}I_1I_2a\left[\frac{1}{x} - \frac{1}{x+a}\right]$$

$$F = \frac{\mu_0}{2\pi}\frac{I_1I_2a^2}{x(x+a)}$$

(away from the infinite straight wire) ½

[CBSE Marking Scheme, 2019]

18. (a) Derive the expression for the torque acting on a current carrying loop placed in a magnetic field.

(b) Explain the significance of a radial magnetic field when a current carrying coil is kept in it. **3**

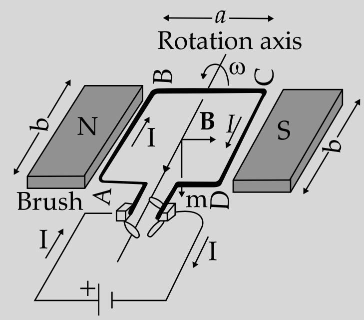
Ans. (a) Derivation of expression for torque **2**

(b) Significance of radial magnetic field. **1**

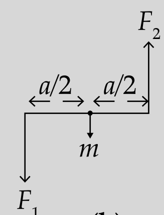
Consider the simple case when a rectangular loop is placed in a uniform magnetic field B that is in the plane of the loop.

Force on arm AB = F_1 = IbB (directed into the plane of the loop)

Force on arm CD = F_2 = IbB (directed into the plane of the loop) ½



(a)



(b) ½

Therefore the magnitude of the torque on the loop due to these pair of forces

$$\tau = F_1\frac{a}{2} + F_2\frac{a}{2}$$ ½

$$= I(ab)B$$

$$= IAB = mB$$ ½

($A = ab$ = area of the loop)

Alternatively,

Also accept if the student does calculations for the general case and obtains the result.

Torque $= IAB\sin\phi$

Alternatively,

Also accept if the student says that the equivalent magnetic moment (m), associated with a current carrying loop is

$\vec{m} = IA\hat{n}$ (A = Area of loop)

The torque, on a magnetic dipole, in a magnetic field, is given by

$$\vec{\tau} = \vec{m} \times \vec{B}$$

$$\therefore \quad \tau = IA(\hat{n} \times \vec{B})$$

Hence

Magnitude of torque is = $IAB \sin \phi$

(b) When a current carrying coil is kept a radial magnetic field the corresponding moving coil galvanometer would have a linear scale. **1**

Alternatively,

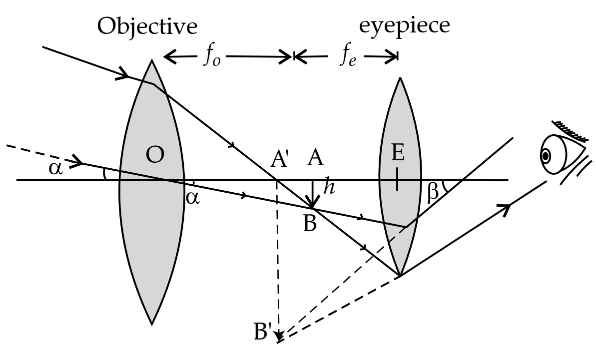
"In a radial magnetic field two sides of the rectangular coil remain parallel to the magnetic field lines while its other two sides remain perpendicular to the magnetic field lines. This holds for all positions of the coil".

[CBSE Marking Scheme, 2019]

19. Draw a labelled ray diagram of an astronomical telescope in the near point adjustment position.

A giant refraction telescope at an observatory has an objective lens of focal length 15 m and an eyepiece of focal length 1.0 cm. If this telescope is used to view the moon, find the diameter of the image of the moon formed by the objective lens. The diameter of the moon is 3.48×10^6 m, and the radius of lunar orbit is 3.8×10^8 m. **3**

Ans.



Magnifying power of telescope, $m = \dfrac{f_o}{f_e}$

here $\quad f_o = 15$ m, $f_e = 1.0$ cm $= 0.01$ m

$$\therefore \quad m = \frac{15}{0.01} = 1500. \qquad \mathbf{1\tfrac{1}{2}}$$

Let D be diameter of moon, d be diameter of image of moon formed by objective and r the distance of moon from objective lens then from figure,

$$\frac{D}{r} = \frac{d}{f_o}$$

$$\Rightarrow \quad d = \frac{D}{r} \cdot f_o$$

$$= \frac{3.48 \times 10^6}{3.8 \times 10^8} \times 15 \text{ m}$$

$$= 0.137 \text{ m} = 13.7 \text{ cm}. \qquad \mathbf{1\tfrac{1}{2}}$$

20. (a) State Gauss's law for magnetism. Explain its significance.

(b) Write the four important properties of the magnetic field lines due to a bar magnet. 3

OR

Write three points of differences between para, dia and ferro- magnetic materials, giving one example for each. 3

Ans. (a)Statement of Gauss's law in magnetism **½**

Its significance **½**

(b) Four Important properties **½ ×4**

(a) Gauss's law for magnetism states that "The total flux of the magnetic field, through any closed surface, is always zero. ½

Alternatively,

$$\oint_S \vec{B}.\vec{ds} = 0$$

This law implies that magnetic monopoles do not exist / magnetic field lines form closed loops. ½

[Note: Award this 1 mark if the student just attempts it].

(b) Four properties of magnetic field lines.

(i) Magnetic field lines always form continuous closed loops. ½

(ii) The tangent to the magnetic field line at a given point represents the direction of the net magnetic field at that point. ½

(iii) The larger the number of field lines crossing per unit area, the stronger is the magnitude of the magnetic field. ½

(iv) Magnetic field lines do not intersect. ½

[CBSE Marking Scheme, 2019]

OR

Three points of difference **3×½**

One example of each **1 ½**

	Diamagnetic	Paramagnetic	Ferromagnetic	
1	$-1 \le \chi < 0$	$-1 < \chi < \varepsilon$	$\chi >> 1$	½
2	$0 \le \mu_r < 1$	$0 \le \mu_r < (1 + \varepsilon)$	$\mu_r >> 1$	½
3	$\mu < \mu_0$	$\mu > \mu_0$	$\mu >> \mu_0$	½

Where ε is any positive constant.

[**Note:** Give full credit of this part if student write any other three correct difference].

Examples (Any one example of each type)

Diamagnetic materials : Bi, Cu, Pb, Si, water, NaCl, Nitrogen (at STP) ½

Paramagnetic materials : Al, Na, Ca, Oxygen (at STP), Copper chloride ½

Ferromagnetic materials : Fe, Ni, Co, Alnico ½

[CBSE Marking Scheme, 2019]

21. Define the term 'decay constant' of a radioactive sample. The rate of disintegration of a given radioactive nucleus is 10000 disintegrations/s

and 5000 disintegrations/s after 20 hr and 30 hr. respectively from start. Calculate the half life and initial number of nuclei at $t = 0$. 3

Ans. Definition of decay constant 1

Calculation of half life 1

Calculation of initial number of nuclei at t=0 1

The decay constant (λ) of a radioactive nucleus equals the ratio of the instantaneous rate of decay $\left(\frac{\Delta N}{\Delta t}\right)$ to the corresponding instantaneous number of radioactive nuclei. 1

Alternatively,

The decay constant (λ) of a radioactive nucleus is the constant of proportionality in the relation between its rate of decay and number of its nuclei at any given instant.

Alternatively,

$$\left(\frac{\Delta N}{\Delta t}\right) \propto N$$

$$\left(\frac{\Delta N}{\Delta t}\right) = \lambda N$$

The constant (λ) is known as the decay constant 1

Alternatively,

The decay constant equals the reciprocal of the mean life of a given radioactive nucleus.

$$\lambda = \frac{1}{\tau}$$

where,

τ = mean life 1

Alternatively,

The decay constant equal the ratio of *ln* 2 to the half life of the given radioactive element.

$$\lambda = \frac{ln2}{T_{1/2}}$$

where $T_{1/2}$ = Half life 1

Alternatively,

The decay constant of a radioactive element, is the reciprocal of the time in which the number of its nuclei reduces to $\frac{1}{e}$ of its original number. 1

[Note: Do not deduct any mark of this definition, if a student does not write the formula in support of the definition]

We have ½

$R = \lambda N$

R (20 hrs) = 10000 = λN_{20}

R (30 hrs) = 5000 = λN_{30}

$\therefore \quad \frac{N_{20}}{N_{30}} = 2$ ½

This means that the number of nuclei, of the given radioactive nucleus, gets halved in a time of (30 – 20) hours = 10 hours

∴ Half life = 10 hours ½

This means that in 20 hours (=2 half lives), the original number of nuclei must have gone down by a factor of 4.

Hence Rate of decay at t = 0

$$\lambda N_0 = 4\lambda N_{20}$$

=4 × 10000 = 40,000 disintegrations per second ½

[**Note** : Award full marks of the last part of this question even if student does not calculate initial number of nuclei and calculates correctly rate of disintegration at t=0]

i.e., R_0 = 40,000 disintegrations per second

$$N_0 = \frac{40000}{\lambda} = \frac{40000}{ln2} \times 10 \times 60 \times 60$$

$$N_0 = \frac{144 \times 10^7}{0.693} = 2.08 \times 10^9 \text{ nuclei}$$ ½

[CBSE Marking Scheme, 2019]

22. (a) Three photodiodes D_1, D_2 and D_3 are made of semiconductors having band gaps of 2.5 eV, 2 eV and 3 eV respectively. Which of them will not be able to detect light of wavelength 600 nm?

(b) Why photo diodes are required to operate in reverse bias? Explain. 3

Ans. (a) Calculation of energy of a photon of light 1½

(b) Identification of photodiode ½

Why photodiode are operated in reverse bias 1

We have

$$E = h\nu = \frac{hc}{\lambda}$$

$$= \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{600 \times 10^{-9}} J$$

$$= \frac{19.89 \times 10^{-26}}{6 \times 10^{-7} \times 1.6 \times 10^{-19}} eV$$

$$= \frac{19.89}{9.6} eV$$

$$= 2.08 eV$$ ½

The band gap energy of diode D_2 (= 2 eV) is less than the energy of the photon.

Hence diode D_2 will not be able to detect light of wavelength 600 nm. ½

[**Note:** Some student may take the energy of the photon as 2 eV and say that all the three diodes will be able is detect this right, Award them the ½ mark for the last part of identification].

(b) A photodiode when operated in reverse bias, can measure the fractional change in carrier dominated reverse bias current with greater ease. 1

Alternatively,

It is easier is observe the change in current with change to light intensity, if a reverse bias is applied. **[CBSE Marking Scheme, 2019]**

23. (a) Describe briefly the function of the three segments of *n-p-n* transistor.

(b) Draw the circuit arrangement for studying the output characteristics of *n-p-n* transistor in CE configuration. Explain how the output characteristics are obtained. 3

OR

Draw the circuit diagram of a full wave rectifier and explain its working. As so, give the input and output waveform. 3

Ans. (a) Functions of the three segments

½ + ½ + ½

(b) Circuit diagram for studying the output characteristics **1**

Obtaining output characteristics ½

(i) Emitter: supplies the large number of majority carriers for current flow through the transistor. ½

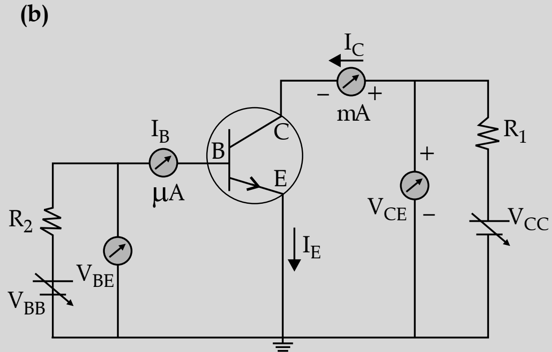
(ii) Base: Allows most of the majority charge carriers to go over to the collector. ½

Alternatively,

It is the very thin lightly doped central segment of the transistor. ½

(iii) Collector: collects a major portion of the majority charge carriers supplied by the emitter. ½

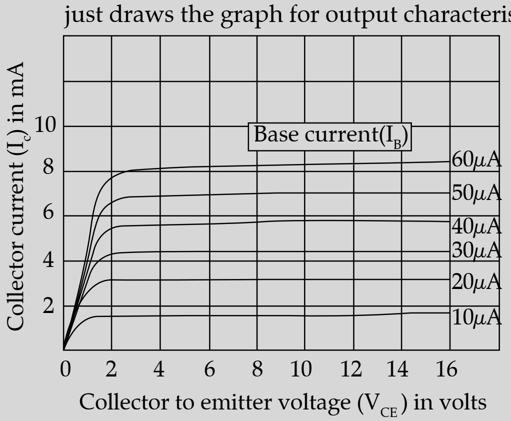
(b)



1

The output characteristics are obtained by observing the variation of I_c when V_{CE} is varied keeping I_B constant. ½

Note : Award the last ½ mark even if the student just draws the graph for output characteristics.



½

[**Note :** Do not deduct marks of this part, for not writing values on the axes].

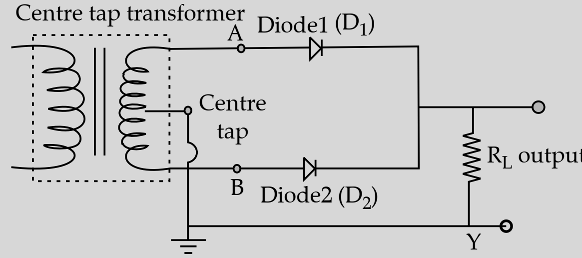
OR

Circuit diagram of full wave rectifier ½

Working Principle ½

Input and Output wave form 1 + 1

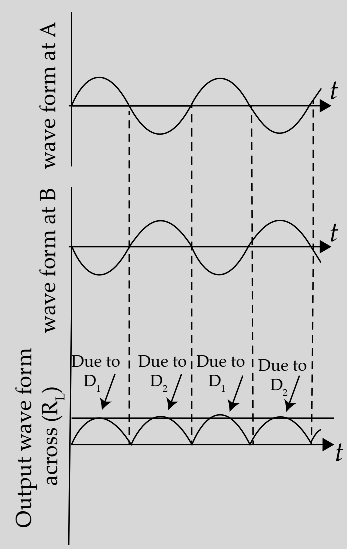
The circuit diagram of a full wave rectifier is shown below.



½

Because of the center tap in the secondary of the transformer, diodes 1 and 2 get forward biased in successive halves of the input *ac* cycle. However the current through the load flows in the same direction in both the halves of the input *ac* cycle. We therefore, get a unidirectional (rectified) current through the load for the full cycle of the input *ac*. ½

The input and output wave forms are as shown below.



1

1

[CBSE Marking Scheme, 2019]

24. (a) If *A* and *B* represent the maximum and minimum amplitudes of an amplitude modulated wave, write the expression for the modulation index in terms of *A* and *B*.

(b) A message signal of frequency 20 kHz and peak voltage 10 V is used to modulate a carrier of frequency 2 MHz and peak voltage of 15 V. Calculate the modulation index. Why the modulation index is generally kept less than one? 3

Ans. (a) Obtaining the expression for modulation index in terms of A and B **1½**

(b) Calculation of μ **1**

Reason **½**

We are given that

$$A = A_c + A_m$$

and $B = A_c - A_m$

$$A_c = (A+B)/2$$

$$A_m = (A-B)/2 \quad \text{½}$$

$$\therefore \mu = \frac{A_m}{A_c}$$

$$= \frac{A-B}{A+B} \quad \text{½}$$

(b) We have

$$\mu = \frac{A_m}{A_c}$$

$$= \frac{10}{15} = \frac{2}{3} \quad \text{½}$$

μ is kept less than one to avoid distortion. ½

[CBSE Marking Scheme, 2019]

SECTION -D

25. (a) In a series LCR circuit connected across an ac source of variable frequency, obtain the expression for its impedance and draw a plot showing its variation with frequency of the ac source.

(b) What is the phase difference between the voltages across inductor and the capacitor at resonance in the LCR circuit?

(c) When an inductor is connected to 200 V dc voltage, a current of 1A flows through it. When the same inductor is connected to a 200 V, 50 Hz ac source, only 0.5 A current flows. Explain why? Also calculate the self inductance of the inductor. **5**

OR

(a) Draw the diagram of a device which is used to decrease high ac voltage into a low ac voltage and state its working principle. Write four sources of energy loss in this device.

(b) A small town with a demand of 1200 kW of electric power at 220 V is situated 20 km away from an electric plant generating power at 440 V. The resistance of the two wire line carrying power is 0.5 Ω per km. The town gets the power from the line through a 4000-220 V step-down transformer at a sub-station in the town. Estimate the line power loss in the form of heat. **5**

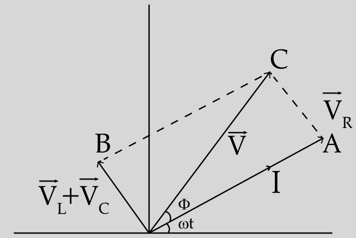
Ans. (a) Derivation of the expression for impedance **2**

Plot of impedance with frequency ½

(b) Phase difference between voltage across inductor and capacitor ½

(c) Reason and calculation of self induction ½+ 1½

(a)



1

$$|\vec{V}| = V_m$$

$$|V_R| = V_{Rm}$$

$$|V_L| = V_{Lm}$$

From the figure, the pythagoras theorem gives

$$V_m{}^2 = V_{Rm}{}^2 + (V_{Lm} - V_{Cm})^2$$

$$V_{Rm} = i_m R, V_{Lm} = i_m X_L, V_{Cm} = i_m X_C$$

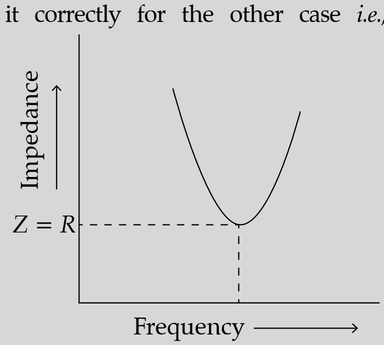
$$V_m = i_m Z$$

$$(V_m)^2 = (i_m Z)^2 = (i_m R)^2 + (i_m X_L - i_m X_C)$$

or, $$Z^2 = R^2 + (X_L - X_C)^2$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2} \quad \text{½}$$

[Note: award these two marks, If a student does it correctly for the other case *i.e.*, ($V_C > V_L$)]



½

(b) Phase difference between voltage across inductor and the capacitor at resonance is 180°. ½

(c) Inductor will offer an additional impedance to *ac* due to its self inductance. ½

$$R = \frac{V_{rms}}{I_{rms}} = \frac{200}{1} = 200\ \Omega$$

Impedance of the inductor

$$Z = \frac{V_{rms}}{I_{rms}} = \frac{200}{0.5} = 400\ \Omega \quad \text{½}$$

Since, $Z = \sqrt{R^2 + (X_L)^2}$

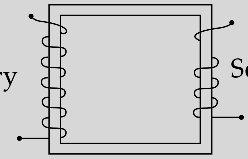
$$\therefore (400)^2 - (200)^2 = (X_L)^2$$

$$X_L = \sqrt{600 \times 200} = 346.4\ \Omega \quad \text{½}$$

$$\text{Inductance } (L) = \frac{X_L}{\omega} = \frac{364.4}{2 \times 3.14 \times 50} = 1.1\,\text{H} \quad \text{½}$$

[CBSE Marking Scheme, 2019]

OR

(a) Primary  Secondary **1**

Working Principle: When the alternating voltage is applied to the primary, the resulting current produces an alternating magnetic flux in secondary and induces an emf in it. It works on the principle of mutual induction. ½

Four sources of energy loss:

(i) Flux leakage between primary and secondary windings. ½

(ii) Resistance of the windings. ½

(iii) Production of eddy currents in the iron core. ½

(iv) Magnetization of the core. ½

(b) Total resistance of the line

= length × resistance per unit length

= 40 km × 0.5 Ω/km

= 20 Ω ½

Current flowing in the line $I = \frac{P}{V}$

$$I = \frac{1200 \times 10^3}{4000}$$

$= 300$ A ½

Line loss in the form of heat

$P = I^2R$

$= (300)^2 \times 20$

$= 1800$ kW ½

[CBSE Marking Scheme, 2019]

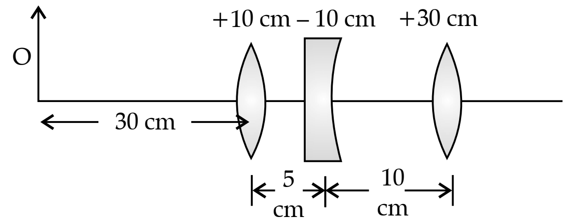
26. (a) Describe any two characteristic features which distinguish interference and diffraction phenomena. Derive the expression for the intensity at a point of the interference pattern in Young's double slit experiment.

(b) In the diffraction due to a single slit experiment, the aperture of the slit is 3 mm. If monochromatic light of wavelength 620 nm is incident normally on the slit, calculate the separation between the first order minima and the 3rd order maxima on one side of the screen. The distance between the slit and the screen is 1.5 m. 5

OR

(a) Under what conditions is the phenomenon of total internal reflection of light observed? Obtain the relation between the critical angle of incidence and the refractive index of the medium.

(b) Three lenses of focal lengths +10 cm, –10 cm and +30 cm are arranged coaxially as in the figure given below. Find the position of the final image formed by the combination. 5



Ans. (a) Two characteristic features of distinction 2

Derivation of the expression for the intensity 1½

(b) Calculation of separation between the first order 1½

(a) (Any two of the following)

(i) Interference pattern has number of equally spaced bright and dark bands while diffraction pattern has central bright maximum which is twice as wide as the other maxima. **1 + 1**

(ii) Interference is obtained by the superposing two waves originating from two narrow slits. The diffraction pattern is the superposition of the continuous family of waves originating from each point on a single slit.

(iii) In interference pattern, the intensity of all bright fringes is same, while in diffraction pattern intensity of bright fringes go on decreasing with the increasing order of the maxima.

(iv) In interference pattern, the first maximum falls at an angle of $\frac{\lambda}{a}$. where *a* is the separation between two narrow slits, while in diffraction pattern, at the same angle first minimum occurs. (where '*a*' is the width of single slit.)

Displacement produced by source S_1

$Y_1 = a\cos \omega t$

Displacement produced by the other source 'S_2' ½

$Y_2 = a\cos(\omega t + \phi)$

Resultant displacement $Y = Y_1 + Y_2$

$= a[\cos \omega t + \cos(\omega t + \phi)$

$= 2a\cos\left(\frac{\phi}{2}\right)\cos(\omega t + \frac{\phi}{2})$ ½

Amplitude of resultant wave

$$A = 2a\cos\left(\frac{\phi}{2}\right)$$

Intensity $I \propto A^2$

$I = KA^2 = K4a^2\cos^2\left(\frac{\phi}{2}\right)$ ½

(b) Distance of first order minima from centre of the central maxima $= X_{D_1} = \frac{\lambda D}{a}$ ½

Distance of third order maxima from centre of the central maxima $X_{B_3} = \frac{7D\lambda}{2a}$ ½

$\therefore$ Distance between first order minima and third order maxima = $X_{B_3} - X_{D_1}$

$$= \frac{7D\lambda}{2a} - \frac{\lambda D}{a}$$
$$= \frac{5D\lambda}{2a}$$
$$= \frac{5 \times 620 \times 10^{-9} \times 1.5}{2 \times 3 \times 10^{-3}}$$
$$= 775 \times 10^{-6} \text{m}$$
$$= 7.75 \times 10^{-4} \text{m}$$ ½

[CBSE Marking Scheme, 2019]

OR

(a) Two conditions of total internal reflection **1+1**

(b) Obtaining the relation **1**

(c) Calculating of the position of the final image **2**

(a)

(i) Light travels from denser to rarer medium. **1**

(ii) Angle of incidence is more than the critical angle **1**

(b) For the Grazing incidence

$$\mu \sin i_C = \sin 90^\circ$$
$$\mu = \frac{1}{\sin i_C}$$ ½

(c) For convex lens of focal length 10 cm

$$\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u_1}$$
$$\frac{1}{10} = \frac{1}{v_1} - \frac{1}{-30} \Rightarrow v_1 = 15 cm$$ ½

Object distance for concave lens

$u_2 = 15 - 5 = 10$ cm

$$\frac{1}{f_2} = \frac{1}{v_2} - \frac{1}{u_2}$$
$$\frac{1}{-10} = \frac{1}{v_2} - \frac{1}{10}$$
$$v_2 = \infty$$ ½

For third lens

$$\frac{1}{f_3} = \frac{1}{v_3} - \frac{1}{u_3}$$
$$\frac{1}{30} = \frac{1}{v_3} - \frac{1}{\infty}$$
$$v_3 = 30 \text{ cm}$$ ½

[CBSE Marking Scheme, 2019]

27. (a) Describe briefly the process of transferring the charge between the two plates of a parallel plate capacitor when connected to a battery. Derive an expression for the energy stored in a capacitor.

(b) A parallel plate capacitor is charged by a battery to a potential difference *V*. It is disconnected form battery and then connected to another uncharged capacitor of the same capacitance. Calculate the ratio of the energy stored in the combination to the initial energy on the single capacitor. **5**

OR

(a) Derive an expression for the electric field at any point on the equatorial line of an electric dipole.

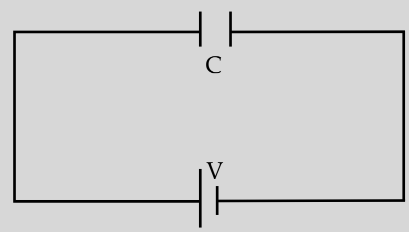
(b) Two identical point charges, *q* each, are kept 2 m apart in air. A third point charge *Q* of unknown magnitude and sign is placed on the line joining the charges such that the system remains in equilibrium. Find the position and nature of *Q*.

Ans. (a) Description of the process of transferring the charge. **½**

Derivation of the expression of the energy stored. **2 ½**

(b) Calculation of the ratio of energy stored. **2**

(a)



The electrons are transferred to the positive terminal of the battery from the metallic plate connected to the positive terminal, leaving behind positive charge on it. Similarly, the electrons move on to the second plate from negative terminal, hence it gets negatively charged. Process continuous till the potential difference between two plates equals the potential of the battery. ½

[**Note :** award this ½ mark, If the student writes, there will be no transfer of charge between the plates.]

Let '*dw*' be the work done by the battery in increasing the charge on the capacitor from *q* to (*q* + *dq*).

$$dw = V\, dq$$ ½

Where $V = \frac{q}{C}$ ½

$$\therefore \quad dw = \frac{q}{C}\, dq$$ ½

Total work done in changing up the capacitor

$$W = \int dw = \int_0^Q \frac{q}{C} dq$$ ½

$$\therefore W = \frac{Q^2}{2C}$$

Hence energy stored,

$$W = \frac{Q^2}{2C}\left(= \frac{1}{2}CV^2 = \frac{1}{2}QV\right)$$ ½

(b) Charge stored on the capacitor $q = CV$

When it is connected to the uncharged capacitor of same capacitance, sharing of charge takes place between the two capacitor till the potential of both the capacitor becomes $\frac{V}{2}$. ½

Energy stored on the combination,

$$U_2 = \frac{1}{2}C\left(\frac{V}{2}\right)^2 + \frac{1}{2}C\left(\frac{V}{2}\right)^2 = \frac{CV^2}{4}$$ ½

Energy stored on single capacitor before connecting $U_1 = \frac{1}{2}CV^2$ ½

Ratio of energy stored in the combination to that in the single capacitor

$$\frac{U_2}{U_1} = \frac{CV^2/4}{CV^2/2} = 1:2$$ ½

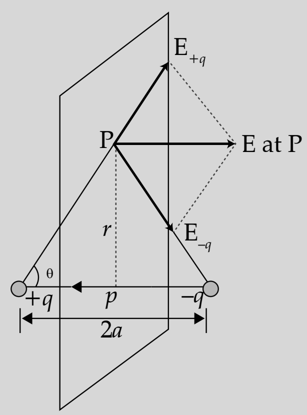
[CBSE Marking Scheme, 2019]

OR

(a) Derivation for the expression of the electric field on the equatorial line **3**

(b) Finding the position and nature of Q **1 + 1**

(a)



1

The magnitude of the electric fields due to the two charges $+q$ and $-q$ are

$$E_{+q} = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r^2+a^2)}$$ ½

$$E_{-q} = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r^2+a^2)}$$ ½

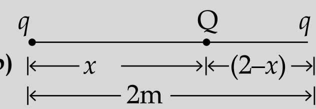
The components normal to the dipole axis cancel away and the components along the dipole axis add up.

Hence,

Total Electric field $= -(E_{+q} + E_{-q})\cos\theta\hat{p}$ ½

$$E = \frac{2qa}{4\pi\varepsilon_0(r^2+a^2)^{\frac{3}{2}}}\hat{p}$$ ½

(b)



½

System is in equilibrium therefore net force on each charge of system will be zero.

For the total force on 'Q' to be zero

$$\frac{1}{4\pi\varepsilon_0}\frac{qQ}{x^2} = \frac{1}{4\pi\varepsilon_0}\frac{qQ}{(2-x)^2}$$ ½

$$x = 2 - x$$

$$2x = 2$$ ½

$$x = 1 \text{ m}$$

(Give full credit of this part, if a students writes directly 1m by observing the given condition).

For the equilibrium of charge "q" the nature of charge Q must be opposite to the nature of charge q. ½

[CBSE Marking Scheme, 2019]

Delhi Set- II 55/1/2

Note: Except these, other questions are from Delhi Set-I.

SECTION -A

2. When unpolarised light is incident on the interface separating the rarer medium and the denser medium, Brewster angle is found to be 60°. Determine the refractive index of the denser medium. **1**

Ans. $\mu = \tan i_p$

$i_p = 60°$

$\mu = \tan 60° = \sqrt{3}$ **1**

[CBSE Marking Scheme, 2019]

4. When a potential difference is applied across the ends of a conductor, how is the drift velocity of the electrons related to the relaxation time? **1**

Ans. $v_d = \frac{eE}{m}\tau$ **1**

Alternatively:

$v_d = \frac{eE}{m}\tau$ **1**

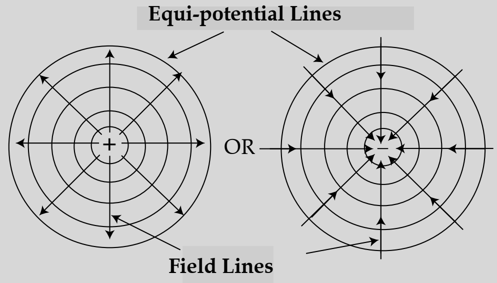
Alternatively,

$v_d \propto \tau$ **1**

[CBSE Marking Scheme, 2019]

5. Draw the equipotential surfaces due to an isolated point charge. **1**

Ans.



1

[CBSE Marking Scheme, 2019]

SECTION -C

13. (a) State the underlying principle of a moving coil galvanometer.

(b) Give two reasons to explain why a galvanometer cannot as such be used to measure the value of the current in a given circuit.

(c) Define the terms: (i) voltage sensitivity and (ii) current sensitivity of a galvanometer. **3**

Ans. (a) Principle **1**

(b) Two reasons **½+ ½**

(c) Definitions of voltage sensitivity and current sensitivity **(½+ ½)**

(a) 'A current carrying coil can experience a torque in a magnetic field.' **1**

(b) (i) Galvanometer is a very sensitive device, it gives a full scale deflection for a current of the order of a few μA. ½

(ii) Resistance of galvanometer is not very small, hence it will change the value of current in the circuit branch when connected (in series in that branch). ½

(c) Current sensitivity is defined as the deflection per unit current. ½

(**Alternatively,** current sensitivity = $\frac{\phi}{I}$)

Voltage sensitivity is defined as the deflection per unit potential difference applied. ½

(**Alternatively,** Voltage sensitivity = $\frac{\phi}{V}$)

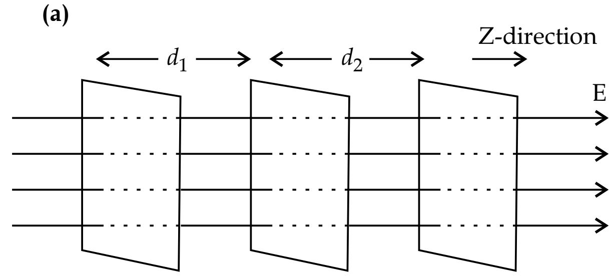
[CBSE Marking Scheme, 2019]

15. (a) Draw equipotential surfaces corresponding to the electric field that uniformly increases in magnitude along with the Z-direction.

(b) Two charges – q and + q are located at point (0, 0, – a) and (0, 0, a). What is the electrostatic potential at the points (0, 0, ± z) and (x, y, 0)? **3**

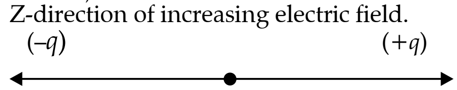
Ans.

(a)



$d_1 > d_2$, this distance decreases as you move across Z-direction of increasing electric field. **1**

(b)



Potential at pt. (0, 0, z)

$$V_z = \frac{kq}{(z-a)} + \frac{k(-q)}{(z+a)} \text{ if } z > a$$

$$= Kq\left[\frac{1}{z-a} - \frac{1}{z+a}\right] = Kq\ \frac{2a}{z^2 - a^2} \qquad \mathbf{1}$$

Potential at $pt.$ (0, 0 – z)

$$V_{(-z)} = \frac{Kq}{(z-a)} + \frac{K(-q)}{(z+a)}$$

$$= Kq\left[\frac{1}{z-a} - \frac{1}{z+a}\right]$$

$$= Kq\ \frac{2a}{z^2 - a^2}$$

$\because r$ for the point is $\sqrt{x^2 + y^2 + a^2}$

$$\therefore \quad V_{(x,\,y,\,0)} = \frac{Kq}{(x^2 + y^2 + a^2)^{½}} + \frac{K(-q)}{(x^2 + y^2 + a^2)^{½}} \qquad \mathbf{1}$$

$$= 0.$$

17. (a) Write the relation between half life and average life of a radioactive nucleus.

(b) In a given sample two isotopes, A and B are initially present in the ratio of 1 : 2. Their half lives are 60 years and 30 years respectively. How long will it take so that the sample has these isotopes in the

Here **ratio of 2 : 1?** **3**

Ans. (a) Relation between average life and half life **1**

(b) Finding the required time **2**

(a) $T = \frac{1}{\lambda}$

Alternatively $\left(\frac{T_{½}}{\ln 2}\right) / \left(\frac{T_{½}}{0.6931}\right) / 1.44\, T_{½}$

(b) We have $N = N_0 e^{-\lambda t}$ **1**

$$\frac{N_{01}}{N_{02}} = \frac{1}{2}, \quad \frac{N_1}{N_2} = \frac{2}{1}$$

$$\therefore \quad \frac{N_1}{N_2} = \frac{N_{01}}{N_{02}} \exp(-(\lambda_1 - \lambda_2)t)$$

$$\therefore \quad 2 = \frac{1}{2}\exp(-(\lambda_1 - \lambda_2)t)$$

$$\Rightarrow \exp(-(\lambda_1 - \lambda_2)t) = 4$$

$$\Rightarrow \quad -(\lambda_1 - \lambda_2)t = 2\ln 2$$

$$\Rightarrow -\ln 2\left(\frac{1}{60} - \frac{1}{30}\right)t = 2$$

$$\Rightarrow \frac{t}{60} = 2$$

$$\Rightarrow t = 120 \text{ years}$$ ½

(**Note :** Also accept if the student gets the answer just through reasoning without using this formula based approach).

[CBSE Marking Scheme, 2019]

Delhi Set- III 55/1/3

Note: Except these, all other questions are from Delhi Set-I & II.

SECTION -A

1. Distinguish between unpolarized and linearly polarized light. 1

Ans. When light is passed through a polaroid, its intensity is reduced to half and does not change on the rotation of the polaroid, the light is unpolarized.

When the intensity of transmitted light changes on rotation of the polaroid, light is polarized. **1**

Alternatively,

In Polarized/ unpolarized light, there is some restriction/no restriction on the vibrations of its electric (and magnetic) field vectors. **1**

[**Note :** Award full marks to the student if he/she explains through the diagram only]

[CBSE Marking Scheme, 2019]

3. How is the drift velocity in a conductor affected with the rise in temperature? 1

Ans. Decreases. **1**

[CBSE Marking Scheme, 2019]

SECTION -B

11. Obtain the expression for the ratio of the de Broglie wavelengths associated with the electron orbiting in the second and third excited states of hydrogen atom. 2

Ans. $2\pi r = n\lambda$ ½

For second excited state (n=3)

$r = 0.529(n)^2$ Å

$= 0.529(3)^2$ ½

$\Rightarrow 2\pi(0.529)(3)^2 = 3\lambda_2$

For third excited state $n = 4$

$r = 0.529\ (4)^2$

$\Rightarrow 2\pi(0.529)(4)^2 = 4\lambda_3$ ½

$$\Rightarrow \frac{3\lambda_2}{4\lambda_3} = \frac{(3)^2}{(4)^2}$$

$$\frac{\lambda_2}{\lambda_3} = 3:4$$ ½

Alternatively,

$2\pi\ (0.53n^2) = n\lambda$ ½

$\Rightarrow \quad \lambda \propto n$

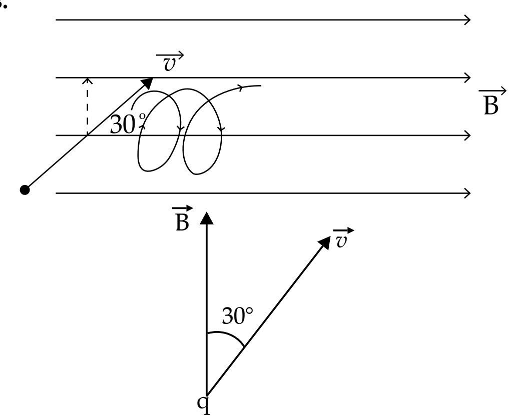
$$\Rightarrow \frac{\lambda_2}{\lambda_3} = \frac{(n)\text{for second excited state}}{(n)\text{for third excited state}}$$

$$\therefore \frac{\lambda \text{ for second excited state}}{\lambda \text{ for third excited state}} = \frac{3}{4}$$ ½

[CBSE Marking Scheme, 2019]

12. A charged particle q is moving in the presence of a magnetic field B which is inclined to an angle 30° with the direction of motion of the particle. Draw the trajectory followed by the particle in the presence of the field and explain how the particle describes this path. 2

Ans.



1

Since magnetic force is given as,

$$\vec{F} = q(\vec{v} \times \vec{B})$$

or $F = qvB\sin\theta$

here, $\theta = 30°$

$$F = \frac{qvB}{2}$$ **1**

Velocity component parallel to the field moves particle in straight line and velocity component perpendicular to the field creates circular motion thus the combined effect is the helical path.

SECTION -C

13. (a) Explain briefly how Rutherford scattering of α-particle by a target nucleus can provide information on the size of nucleus.

(b) Show that density of nucleus is independent of its mass number A. 3

Ans. (a) Explanation of information on the size of nucleus **1½**

(b) Showing the independence of density on mass number **1½**

(a) Many of the α-particles pass through the foil. A few particles deflect by more than 90°. ½

Rutherford argued that to deflect the α-particles backward, it must experience a large repulsive force. ½

It shows that most of the part of an atom is the empty space and its positive charge is concentrated tightly at its centre and its size is very small as compared to the size of atom. ½

(nearly $\frac{1}{10,000}$ to $\frac{1}{10,000}$ times the size of atom)

Alternatively,

In Rutherford experiment, the calculation of distance of closest approach provides information about the size of the nucleus.

Let K be the initial kinetic energy of the alpha particle.

At the distance of closest approach

$$\frac{1}{4\pi\varepsilon_0}\frac{(Ze)(2e)}{a^2} = k$$

$$\therefore \qquad a = \frac{2Ze^2}{4\pi\varepsilon_0 k}$$

(b) Radius of the nucleus of mass number A, $R = R_0A^{1/3}$, where, R_0 is constant. ½

Volume of the nucleus,

$$V = \frac{4}{3}\pi R^3$$

$$= \frac{4}{3}\pi\left(R_0A^{1/3}\right)^3$$

$$= \frac{4}{3}\pi AR_0^{\ 3}$$

$$\text{Density}(\rho) = \frac{\text{mass}}{\text{volume}} = \frac{mA}{\left(\frac{4}{3}\pi R_0^{\ 3}A\right)}$$

$$= \frac{3m}{4\pi R_0^{\ 3}}$$ ½

i.e., independent of mass number A.

[CBSE Marking Scheme, 2019]

14. State the underlying principle of a cyclotron. Explain its working with the help of a schematic diagram. Obtain the expression for cyclotron frequency. 3

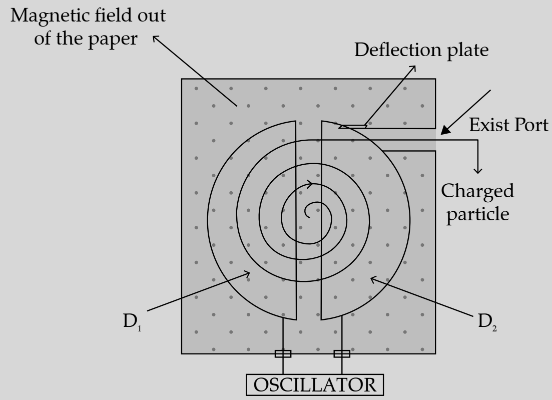
Ans. Underlying principle of cyclotron ½

Working 1

Schematic diagram ½

Obtaining the expression for the cyclotron frequency 1

Cyclotron works on the principle that kinetic energy of the charged particle is increased when they move in crossed oscillating electric and magnetic fields again and again. ½



½

When charged particle enters inside the metal boxes, no electric field acts on it, the magnetic field however acts on the particle and makes it go round on a circular path inside the metal boxes, every time when particle moves one dee to another it is acted upon by the electric field and the sign of electric field changes alternatively in turn with the circular motion of the particle, hence particle is accelerated, which in turn increases the kinetic energy of it. **1**

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

$$r = \frac{mv}{qB}$$

Frequency,

$$\nu = \frac{v}{2\pi r}$$

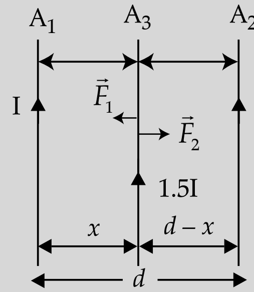
$$= \frac{v}{2\pi\left(\frac{mv}{qB}\right)} = \frac{qB}{2\pi m}$$ **1**

Thus, frequency is independent of the speed 'v' and radius 'r'.

[CBSE Marking Scheme, 2019]

15. Two infinitely long straight wires A_1 and A_2 carrying currents I and $2I$ flowing in the same direction are kept 'd' distance apart. Where should a third straight wire A_3 carrying current 1.5I be placed between A_1 and A_2 so that it experiences no net force due to A_1 and A_2? Does the net force acting on A_3 depend on the current flowing through it? 3

Ans. Finding the position of third wire
Reason



½

$$\Rightarrow \quad F_1 = \frac{\mu_0}{4\pi}\frac{I \times 1.5I}{x}$$

$$F_2 = \frac{\mu_0}{4\pi}\frac{2I \times 1.5I}{(d-x)}$$ ½

For no force on the conductor A_3

$$\frac{\mu_0}{4\pi}\frac{I \times 1.5I}{x} = \frac{\mu_0}{4\pi}\frac{2I \times 1.5I}{(d-x)}$$

$$\frac{1}{x} = \frac{2}{(d-x)}$$

$$3x = d$$

$$x = \frac{d}{3}$$ ½

[**Note :** Also accept in general it will depend on the value of I_3].

[CBSE Marking Scheme, 2019]

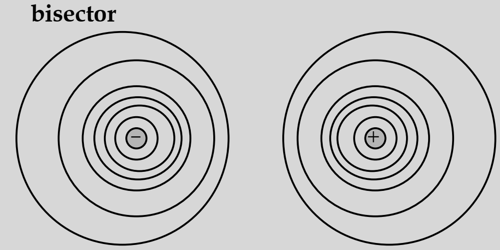
16. (a) Draw the equipotential surfaces due to an electric dipole. 3

(b) Derive as expression for the electric field due to a dipole of dipole moment $\vec{p}$ at a point on its perpendicular bisector.

Ans. (a) Drawing of equipotential surfaces due to an electric dipole 1

(b) Derivation of electric field on the perpendicular bisector 2

(a)



1

(b) [Try yourself similar to Ques 27 (OR (a) part) Delhi Set-I]

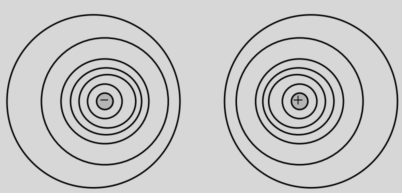
[CBSE Marking Scheme, 2019]

Outside Delhi-I 55/2/1

SECTION -A

1. Draw equipotential surfaces for an electric dipole. 1

Ans.



1

(Even if a student mentions or draws equatorial plane, award 1 mark.)

[CBSE Marking Scheme, 2019]

2. A proton is accelerated through a potential difference *V*, subjected to a uniform magnetic field acting normal to the velocity of the proton. If the potential difference is doubled, how will the radius of the circular path described by the proton in the magnetic field change? 1

Ans. For writing the expression for radius ½

To find the change in the radius of the circular orbit ½

Alternatively,

$$r = \frac{1}{B}\sqrt{\frac{2mV}{q}}$$

$$r' = \sqrt{2}r$$

$$r \propto \sqrt{V}$$

$$\frac{r'}{r} = \sqrt{2}$$ ½

Note : Even if student writes $Bqv = \frac{mv^2}{R}$, award one mark **[CBSE Marking Scheme, 2019]**

3. The magnetic susceptibility of magnesium at 300 K is 1.2 × 10^5. At what temperature will its magnetic susceptibility become 1.44 × 10^5? 1

OR

The magnetic susceptibility χ of a given material is –0.5. Identify the magnetic material.

Ans. • For writing relationship between susceptibility and temperature ½

• Calculating the temperature ½

$$\chi_m \propto \frac{1}{T}$$

$$T_2 = \frac{\chi_{m1}}{\chi_{m2}} \times T_1$$

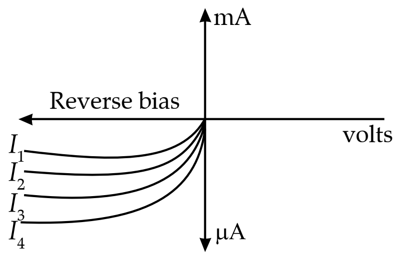
$$T_2 = \frac{1.2 \times 10^5}{1.44 \times 10^5} \times 300 = 250\,\text{K}$$ ½

[CBSE Marking Scheme, 2019]

OR

- **For identification of magnetic material**
  It is diamagnetic material.
  [CBSE Marking Scheme, 2019]

4. Identify the semiconductor diode whose V−I characteristics are as shown: 1



$I_4 > I_3 > I_2 > I_1$

- **For identification of semiconductor diode**
  It is photodiode.
  [CBSE Marking Scheme, 2019]

5. Which part of the electromagnetic spectrum is used in RADAR? Give its frequency range. 1

OR

How are electromagnetic waves produced by accelerating charges? 1

Ans. To identify the part of the electromagnetic spectrum
For writing its frequency range
Microwaves
Frequency range is 10^{10} to 10^{12} Hz 1
[CBSE Marking Scheme, 2019]

OR

Ans. Production of EM waves:
Electromagnetic waves consist of both electric and magnetic fields travelling through empty space with the speed of light *c*. These waves oscillate in perpendicular planes with respect to each other and are in phase. An electromagnetic wave can be created by accelerating charges; moving charges back and forth, producing oscillating electric and magnetic fields. When the accelerating charged particle moves with acceleration, both magnetic and electric fields change continuously which lead to production of electromagnetic waves. 1

SECTION -B

6. A capacitor made of two parallel plates, each of area '*A*' and separation '*d*' is charged by an external dc source. Show that during charging, the displacement current inside the capacitor is the same as the current charging the capacitor. 2

Ans. For writing expression for total current 1
For showing that displacement current is the same as the current charging the capacitor 1
$i = i_c + i_d$
where, i_c is conduction current and i_d is displacement current.
Outside the capacitor $i_d = 0$ so $i = i_c$ ½
Inside the capacitor $i_c = 0$ so $i = i_d$ ½
[CBSE Marking Scheme, 2019]

7. A photon and a proton have the same de-Broglie wavelength λ. Prove that the energy of the photon is ($2m\lambda c/h$) times the kinetic energy of the proton. 2

Ans. For writing expression for energy of photon ½
For writing expression for kinetic energy of proton 1
For proving the relationship between the two ½

Energy of photon, $E_p = \dfrac{hc}{\lambda}$ ½

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

$mv = \dfrac{h}{\lambda}$ ½

Kinetic energy of proton,

$E_k = \dfrac{1}{2}mv^2$ ½

$E_k = \dfrac{1}{2}\dfrac{h^2}{m\lambda^2}$

$E_p = \left(\dfrac{2m\lambda c}{h}\right)E_k$

[CBSE Marking Scheme, 2019]

8. A photon emitted during the de-excitation of electron from a state *n* to the first excited state in a hydrogen atom, irradiates a metallic cathode of work function 2 eV, in a photo cell, with a stopping potential of 0.55 V. Obtain the value of the quantum number of the state *n*. 2

OR

A hydrogen atom in the ground state is excited by an electron beam of 12.5 eV energy. Find out the maximum number of lines emitted by the atom from its excited state. 2

Ans.
- For writing Einstein's photoelectric equation ½
- For writing, $E_n = -\dfrac{13.6}{n^2}$ ½
- For finding the value of n 1

From photoelectric equation, $h\nu = \phi_0 + eV_s$ ½

$= 2 + 0.55 = 2.55$ eV

Given, $E_n = \dfrac{13.6}{n^2}$

The energy difference

$\Delta E = -3.4 - (-2.55)$ eV $= -0.85$ eV ½

$\therefore \quad \dfrac{-13.6}{n^2} = -0.85$ ½

$\therefore \quad n = 4$ **[CBSE Marking Scheme, 2019]** ½

OR

Calculation of energy in excited state ½
Formula ½
Finding out the maximum number of lines. 1

Energy in ground state, $E_1 = -13.6$ eV
Energy supplied = 12.5 eV
Energy in excited state, –13.6+ 12.5 = –1.1 eV ½

But, $E_n = \frac{-13.6}{n^2} = -1.1$ ½

$n = 3$ ½

Maximum number of lines=3 ½

[CBSE Marking Scheme, 2019]

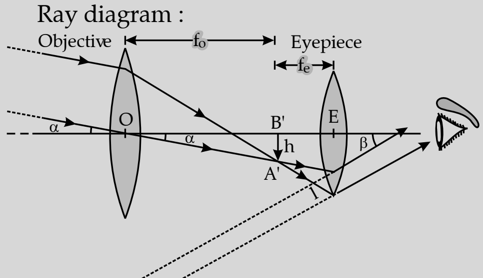
9. Draw the ray diagram of an astronomical telescope showing image formation in the normal adjustment position. Write the expression for its magnifying power. 2

OR

Draw a labelled ray diagram to show image formation by a compound microscope and write the expression for its resolving power. 2

Ans. To draw the ray diagram of astronomical telescope 1 ½
Expression for magnification ½

Ray diagram :



1½

Magnification $= \frac{f_o}{f_e}$

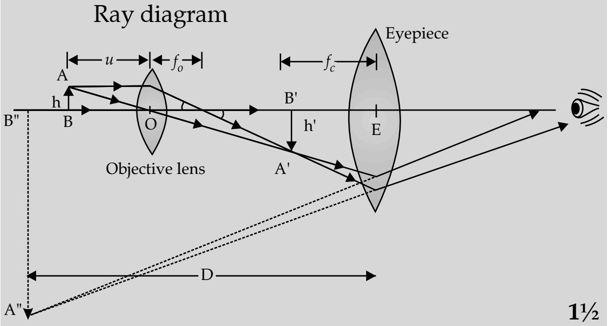
or $m = \frac{\beta}{\alpha}$ ½

[CBSE Marking Scheme, 2019]

OR

To draw the ray diagram of compound microscope
Expression for resolving power

Ray diagram



1½

Resolving power $= \frac{2n\sin\beta}{1.22\lambda}$ ½

[CBSE Marking Scheme, 2019]

***10. Write the relation between the height of a TV antenna and the maximum range up to which signals transmitted by the antenna can be received. How is this expression modified in the case of line of sight communication by space waves? In which range of frequencies, is this mode of communication used?** 2

11. Under which conditions can a rainbow be observed? Distinguish between a primary and a secondary rainbow. 2

Ans. Conditions 1
Distinction between primary and secondary rainbow 1

Conditions:

(i) Sun must be on the back side of the observer. ½

(ii) Presence of water droplets.

Distinction between the primary and secondary rainbow. ½

S.No	Primary rainbow	Secondary rainbow	
1.	Internal reflection takes place once.	Internal reflection takes place twice.	½
2.	Intensity is higher	Intensity is low	½

[Note : Even if student attempts by writing just the Q. No. or student just writes TIR (total internal reflection) etc. award full two marks].

[CBSE Marking Scheme, 2019]

12. Explain the following :

(a) Sky appears blue.

(b) The Sun appears reddish at (i) sunset, (ii) sunrise. 2

Ans. Explaining the cause of bluish colour of sky 1
Appearance of sun red at the time of sun rise and sun set 1

(a) Scattering is inversely proportional to the fourth power of wavelength. 1

OR

Shorter wavelength scatters more hence sky appear blue.

(b) Red colour is least scattered. So by the time light reaches the surface of earth all the colours except red get scattered away. 1

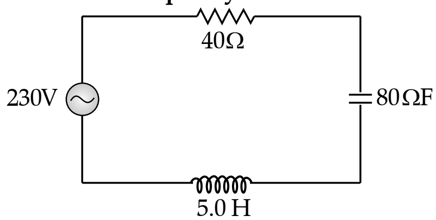
[CBSE Marking Scheme, 2019]

SECTION -C

13. A capacitor (*C*) and resistor (*R*) are connected in series with an ac source of voltage of frequency 50 Hz. The potential difference across *C* and *R* are respectively 120 V, 90 V, and the current in the circuit is 3 A. Calculate (i) the impedance of the circuit (ii) the value of the inductance, which when connected in series with *C* and *R* will make the power factor of the circuit unity. 3

OR

The figure shows a series LCR circuit connected to a variable frequency 230 V source. **3**



(a) Determine the source frequency which drives the circuit in resonance.
(b) Calculate the impedance of the circuit and amplitude of current at resonance.
(c) Show that potential drop across LC combination is zero at resonating frequency.

Ans. Calculation of impedance **2**
Calculation of inductance **1**

(i) $Z = \sqrt{R^2 + X_C^2}$ ½

$R = \frac{V_R}{I_R} = 30\,\Omega$ ½

$X_C = \frac{V_C}{I_C} = \frac{120}{30} = 40\Omega$ ½

$Z = \sqrt{(30)^2 + (40)^2} = 50\Omega$ ½

$X_C = X_L$

(ii) As power factor =1

$100\pi L = 40$ ½

$L = \frac{2}{5\pi}$ henry ½

[CBSE Marking Scheme, 2019]

OR

Determining the source frequency **1**
Calculating impedance **½**
For showing potential drop across LC **1 ½**

(a) $\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{5 \times 80 \times 10^{-6}}} = \frac{1}{\sqrt{400 \times 10^{-6}}}$

$\omega = \frac{1000}{20} = 50\,Hz$ **1**

(b) $Z = R = 40\,\Omega$

$\omega = \frac{1000}{20} = 50\,Hz$ ½

$I_m^{max} = \frac{230\sqrt{2}}{R} = \frac{230\sqrt{2}}{40} = 8.1\,A$ ½

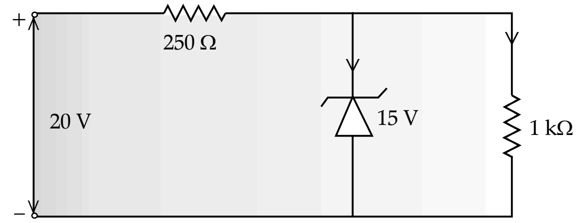
$V_c = I_m^{max} X_c = \frac{230\sqrt{2}}{40} \times \frac{1}{\omega C} = 2033$ volt

$V_L = I_m^{max} X_L = \frac{230\sqrt{2}}{40} \times 2\pi\nu\, L = 2033$ volt ½

(c) $V_C - V_L = 0$ ½

[CBSE Marking Scheme, 2019]

14. Give reason to explain why *n* and *p* regions of a Zener diode are heavily doped. Find the current through the Zener diode in the circuit given below (Zener breakdown voltage is 15 V).



Ans. Reason to explain why *n-p* region of zener diode is heavily doped **1½**

Calculation of current through zener diode **1½**

n and *p* regions of zener diode are heavily doped so that depletion region formed is very thin and electric field at the junction is extremely high even for a small reverse bias voltage. **1½**

Current in the circuit is :

$I = \frac{V}{R} = \frac{5}{250} = \frac{1}{50} = 0.02\,A$ ½

Current through resistor of 1kΩ is:

$I = \frac{15}{1000} = 0.015A$ ½

As zener diode and 1kΩ resistor are in parallel, current through the zener diode is :

$I = 0.02 - 0.015 = 0.005$ A ½

[CBSE Marking Scheme, 2019]

15. Draw a labelled diagram of cyclotron. Explain its working principle. Show that cyclotron frequency is independent of the speed and radius of the orbit. **3**

OR

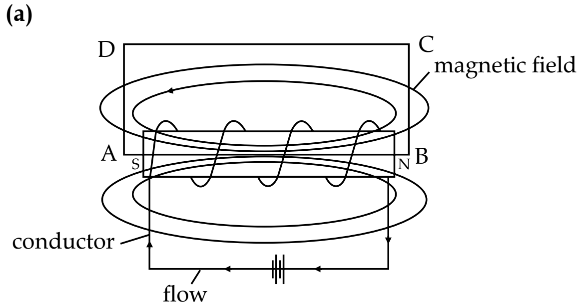
(a) Derive, with the help of a diagram, the expression for the magnetic field inside a very long solenoid having *n* turns per unit length carrying a current *I*.
(b) How is a toroid different from a solenoid? **3**

Ans. [Try yourself, similar to Q.no.14 in Delhi - Set III]

OR

Ans.

(a)



Let us consider a very long straight solenoid having 'n' turns per unit length and carrying electric current 'I' as shown. Let us consider a point well inside the solenoid at which the magnetic induction is to be found.

Consider a rectangular path ABCD of the line of induction such that AB = L = length of the rectangular path. The number of turns enclosed by the rectangles is nL. Hence the total electric current flowing through the rectangular path is nLI. According to Ampere's law,

$$\oint \vec{B}.\vec{dl} = \mu_0 nLI \qquad \text{...(1)½}$$

Now for closed loop

$$\oint \vec{B}.\vec{dl} = \int_A^B \vec{B}.\vec{dl} + \int_B^C \vec{B}.\vec{dl} + \int_C^D \vec{B}.\vec{dl} + \int_D^A \vec{B}.\vec{dl}$$

As the direction of $\vec{dl}$ and $\vec{B}$ in path BC and AD are perpendicular

$$\therefore \quad \int_B^C \vec{B}.\vec{dl} = \int_D^A \vec{B}.\vec{dl} = 0 \qquad \text{½}$$

Near the ends of the solenoid, the lines of the field are crowded. While for rest of the space the lines are so widely spaced that the magnetic field is negligible.

$$\therefore \quad \int_C^D \vec{B}.\vec{dl} = 0$$

Thus

$$\oint \vec{B}.\vec{dl} = \int_A^B \vec{B}.\vec{dl} + 0 + 0 + 0 = \int_A^B \vec{B}.\vec{dl}$$

But $\vec{B}$ and $\vec{dl}$ are in the same direction

$$\vec{B}.\vec{dl} = B.dl.\cos 0° = B.dl$$

$$\oint \vec{B}.\vec{dl} = \int_A^B B.dl = B\int_A^B dl = BL \qquad \text{...(2)}$$

From equation (1) and (2) we get

$$BL = \mu_0 nLI \qquad 1$$

$$B = \mu_0 nI$$

(b) A toroid can be viewed as a solenoid which has been bent into a circular shape to close on itself. 1

16. Prove that the magnetic moment of the electron revolving around a nucleus in an orbit of radius r with orbital speed v is equal to $evr/2$. Hence using Bohr's postulate of quantization of angular momentum, deduce the expression for the magnetic moment of hydrogen atom in the ground state. **3**

Ans. **Proving magnetic moment as $\frac{evr}{2}$** **2**

Deducing expression of the magnetic moment of hydrogen atom **1**

The magnetic moment is

$m = IA$ ½

But current is $I = \frac{e}{T} = \frac{ev}{2\pi r}$ ½

where, $T = \frac{2\pi r}{v}$ and the area, $A = \pi r^2$ ½

$$m = \frac{ev}{2\pi r}\pi r^2 = \frac{evr}{2} \qquad \text{½}$$

But from Bohr's second postulate

$$m_e vr = \frac{nh}{2\pi} = \frac{h}{2\pi} \qquad \text{for } n = 1 \quad \text{½}$$

$$vr = \frac{nh}{2\pi m_e}$$

Hence the magnetic moment is

$$m = \frac{e}{2}\frac{h}{2\pi m_e} = \frac{eh}{4\pi m_e} \quad \text{(Here } n=1) \qquad \text{½}$$

[CBSE Marking Scheme, 2019]

17. Two large charged plane sheets of charge densities σ and –2σ C/m² are arranged vertically with a separation of d between them. Deduce expressions for the electric field at points

(i) to the left of the first sheet, (ii) to the right of the second sheet, and (iii) between the two sheets. **3**

OR

A spherical conducting shell of inner radius r_1 and outer radius r_2 has a charge Q.

(a) A charge q is placed at the centre of the shell. Find out the surface charge density on the inner and outer surfaces of the shell.

(b) Is the electric field inside a cavity (with no charge) zero-independent of the fact whether the shell is spherical or not? Explain. **3**

Ans. Diagram **1+½**

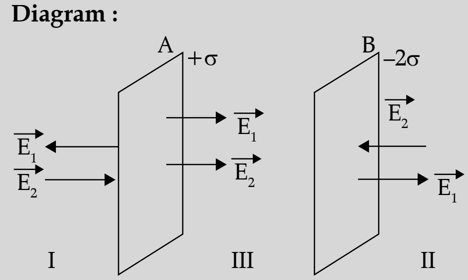
Deducing electric field expression

(i) To the left of first sheet **½**

(ii) To the right of second sheet **½**

(iii) Between the two sheets **½**

Diagram :



1½

Electric field in the region left of first sheet

$$E_I = E_1 + E_2$$

$$E_I = \frac{\sigma}{\varepsilon_0} - \frac{\sigma}{2\varepsilon_0}$$

$$E_I = +\frac{\sigma}{2\varepsilon_0} \qquad \text{½}$$

It is towards right,

Electric field in the region to the right of second sheet

$$E_{II} = \frac{\sigma}{2\varepsilon_0} - \frac{\sigma}{\varepsilon_0}$$

$$E_{II} = -\frac{\sigma}{2\varepsilon_0}$$ ½

It is towards left,

Electric field between the two sheets

$$E_{III} = E_I + E_{II}$$

$$E_{III} = \frac{\sigma}{\varepsilon_0} + \frac{\sigma}{2\varepsilon_0}$$

$$E_{III} = \frac{3\sigma}{2\varepsilon_0}$$ ½

Electric field is towards the right.

[CBSE Marking Scheme, 2019]

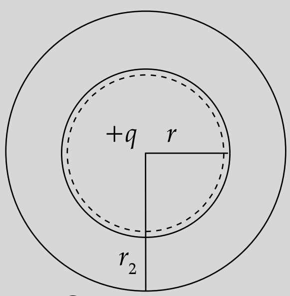
OR

Diagram ½

Finding the surface charge density in the inner and outer surface of the shell 1+½

Electric field in the cavity 1

Diagram:



½

The surface charge density on inner surface of the shell is $\sigma_1 = -\frac{q}{4\pi r_1^2}$ 1

The surface charge density on outer shell is

$$\sigma_2 = -\frac{Q+q}{4\pi r_2^2}$$ ½

(b) Consider a Gaussian surface inside the shell, net flux is zero since $q_{net} = 0$. According to Gauss's law it is independent of shape and size of shell.

[CBSE Marking Scheme, 2019]1

18. A signal of low frequency f_m is to be transmitted using a carrier wave of frequency f_c. Derive the expression for the amplitude modulated wave and deduce expressions for the lower and upper sidebands produced. Hence, obtain the expression for modulation index. 3

Ans. Derive expression for amplitude modulated wave. 2

Deducing expression for lower and upper side bands. ½

Obtaining expression for modulation index. ½

Let a carrier wave be given by

$c(t) = A_c \sin \omega_c t$ where $\omega_c = 2\pi f_c$

And signal wave be

$m(t) \sin \omega_m t$ where $\omega_m = 2\pi f_m$

The modulated signal is

$c_m(t) = (A_c + A_m \sin \omega_m t) \sin \omega_c t$

$$c_m(t) = A_c\left(1 + \frac{A_m}{A_c}\sin \omega_m t\right)\sin \omega_c t$$

$$c_m(t) = A_c \sin \omega_c t + \mu \frac{A_c}{2}\cos(\omega_c - \omega_m)t - \mu \frac{A_c}{2}\cos(\omega_c + \omega_m)t$$ ½

The modulation index $\mu = \frac{A_m}{A_c}$ ½

Lower frequency band $\omega_c - \omega_m$ ½

Upper frequency band $\omega_c + \omega_m$ ½

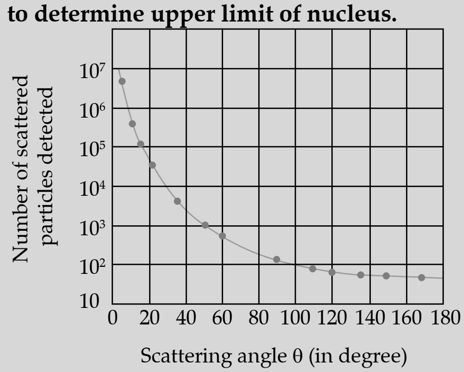
[CBSE Marking Scheme, 2019]

19. Draw a plot of α-particle scattering by a thin foil of gold to show the variation of the number of the scattered particles with scattering angle. Describe briefly how the large angle scattering explains the existence of the nucleus inside the atom. Explain with the help of impact parameter picture, how Rutherford scattering serves a powerful way to determine an upper limit on the size of the nucleus. 3

Ans. Draw a plot of α -particle scattering to show variation of scattering particle. 1

Describe briefly how large scattering explains existence of nucleus. 1

Explain with the help of impact parameter picture how Rutherford scattering serves powerful way to determine upper limit of nucleus. 1



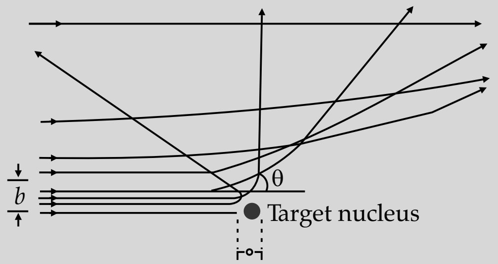
1

The data shows that large number of α-particles do not suffer large scattering but small number suffer greater scattering.

It is concluded that: ½

(i) most of the atom is empty space.

(ii) massive positively charged nucleus occupies small region. ½



½

From the picture it is clear that for small impact parameter suffers large scattering thus it shows the upper limit to the size of nucleus.

[CBSE Marking Scheme, 2019] ½

20. A 200 μF parallel plate capacitor having plate separation of 5 mm is charged by a 100 V dc source. It remains connected to the source. Using an insulated handle, the distance between the plates is doubled and a dielectric slab of thickness 5 mm and dielectric constant 10 is introduced between the plates. Explain with reason, how the (i) capacitance, (ii) electric field between the plates, (iii) energy density of the capacitor will change? **3**

Ans. (i) Change in capacitance **1**

(ii) Change in electric field **1**

(iii) Change in electric density **1**

Dielectric slab of thickness 5 mm is equivalent to an air capacitor of thickness = $\frac{5}{10}$ mm ½

Effective separation between the plates with air in between is = (5 + 0.50) mm = 5.5 mm

(i) Effective new capacitance

$$= 200\mu F \times \frac{5\text{mm}}{5.5\text{mm}} = \frac{2000}{11}\mu F$$

$$\approx 182\mu F$$ **1**

(ii) Effective new electric field

$$= \frac{100\text{V}}{5.5 \times 10^{-3} m} = \frac{20000}{1.1}$$

$$\approx 18182 \text{ V}/m$$ **1**

(iii) $$\frac{\text{New energy stored}}{\text{Original energy stored}} = \frac{\frac{1}{2}C'V^2}{\frac{1}{2}CV^2} = \frac{C'}{C} = \frac{10}{11}$$ **1**

New Energy density will be $\left(\frac{10}{11}\right)^2$ of the original energy density = $\frac{100}{121}$ of the original energy density.

[**Note :** If the student writes $C = \frac{A\varepsilon_0}{d}$

$$C_m = \frac{KA\varepsilon_0}{d}$$

$$E' = \frac{V}{d}$$

$$U = \frac{1}{2}\varepsilon_0 E^2$$

Award full marks.]

[CBSE Marking Scheme, 2019]

21. Why is it difficult to detect the presence of an anti-neutrino during β-decay? Define the term decay constant of a radioactive nucleus and derive the expression for its mean life in terms of the decay constant.

OR

(a) State two distinguishing features of nuclear force.

(b) Draw a plot showing the variation of potential energy of a pair of nucleons as a function of their separation. Mark the regions on the graph where the force is (i) attractive, and (ii) repulsive.

Ans. Reason for difficulty in detecting presence of anti-neutrino during β decay **½**

Define decay constant of radioactive nucleus **½**

Derive expression for mean life in terms of decay constant **2**

- Penetrating power is high
- Do not interact with matter (weak interaction) ½
(any one)
- Decay constant is the reciprocal of the time duration in which undecayed radioactive nuclei reduce to 1/e times the nuclei present initially. **1**

$$\tau = \frac{\text{total life time of all nuclei}}{\text{total number of nuclei}}$$

$$\tau = \frac{\int_0^\infty t dN}{N_0}$$

$$\tau = \frac{\int_0^\infty t(N_0 \lambda \varepsilon^{-\lambda t} dt)}{N_0} = \lambda \int te^{-\lambda t} dt$$

$$\tau = \frac{1}{\lambda}$$ ½

OR

(a) Stating distinguishing feature of nuclear force. **1**

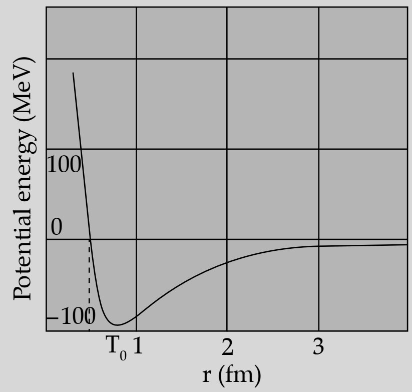
(b) Drawing a plot showing variation of potential energy. **1**

(c) Marking the regions. **½+½**

(1) Short rang force

(2) Strongest force
(3) Attractive in nature
(4) Does not depend on charge (any two) **1**

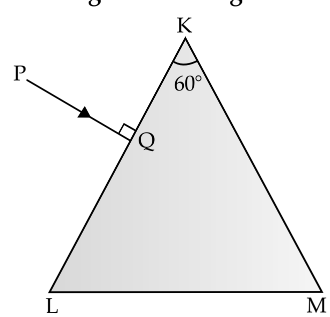
(b)



1

$r < r_0$: repulsive force ½
$r > r_0$: attractive force ½

22. A triangular prism of refracting angle 60° is made of a transparent material of refractive index $\frac{2}{\sqrt{3}}$. A ray of light is incident normally on the face KL as shown in the figure. Trace the path of the ray as it passes through the prism and calculate the angle of emergence and angle of deviation. 3

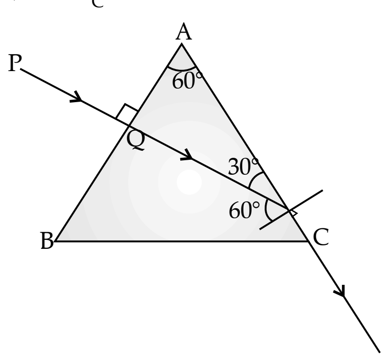


Ans. If i_C is the critical angle for the prism/material,

$$\mu = \frac{1}{\sin i_C}$$

$$\therefore \quad \sin i_C = \frac{1}{\mu} = \frac{\sqrt{3}}{2}$$

$$\Rightarrow \quad i_C = 60°$$ **2**



1

Angle of incidence at face AC of the prism = 60°

Hence, refracted ray grazes the surface AC.

$\Rightarrow$ Angle of emergence = 90°

$\Rightarrow$ Angle of deviation = 30°

23. Prove that in a common-emitter amplifier, the output and input differ in phase by 180°. In a transistor, the change of base current by 30 μA produces change of 0.02 V in the base-emitter voltage and a change of 4 mA in the collector current. Calculate the current amplification factor and the load resistance used, if the voltage gain of the amplifier is 400. 3

Ans. Proving the phase difference 1
Calculation of amplification factor 1
Calculation of load resistance 1

Input signal, $V_i = \Delta I_B r_i$

Input signal, $V_0 = -\Delta I_C R_L$

Voltage amplification, $A_V = \frac{V_0}{V_i}$ ½

- $A_V = -\frac{\Delta I_B}{\Delta I_C} \times \frac{r_i}{R_L}$
- $A_V = -\beta \times$ resistance gain.

Here negative sign indicates that output is 180° out of phase w.r.t. input signal. ½

$$\beta = \frac{\Delta I_C}{\Delta I_B} = \frac{4 \times 10^{-3}}{30 \times 10^{-6}} = \frac{400}{3}$$

- $r_i = \frac{\Delta V_{BE}}{\Delta I_B} = \frac{0.02}{30 \times 10^{-6}} = \frac{2 \times 10^{-2}}{30 \times 10^{-5}}$ **1**
- $r_i = \frac{2}{3} \times 10^3 \Omega$

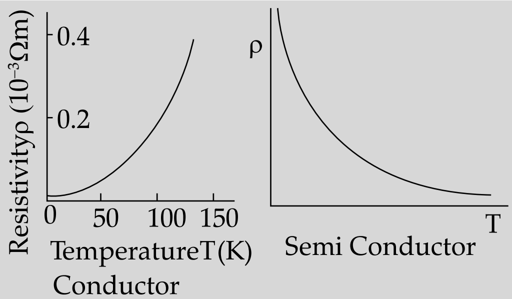
$$A_V = \beta \frac{R_L}{r_i}$$

$$R_L = \frac{A_V \times r_i}{\beta} = \frac{400 \times 2 \times 10^3 \times 3}{400 \times 3} = 2 \times 10^3 \Omega$$ **1**

[CBSE Marking Scheme, 2019]

24. Show, on a plot, variation of resistivity of (i) a conductor, and (ii) a typical semiconductor as a function of temperature.
Using the expression for the resistivity in terms of number density and relaxation time between the collisions, explain how resistivity in the case of a conductor increases while it decreases in a semiconductor, with the rise of temperature. 3

Ans. • **Showing the plot of variation of resistivity** ½+½
- **Expression for resistivity 1**
- **Explaining variation of resistivity for conductor and semiconductor** ½+½



½+½

- $\rho = \dfrac{m}{ne^2\tau}$ **1**
- In case of conductors with increase in temperature, relaxation time decreases, so resistivity increases. ½
- In case of semiconductors with increase in temperature, number density (n) of free electrons increases, hence resistivity decreases. ½

[CBSE Marking Scheme, 2019]

SECTION -D

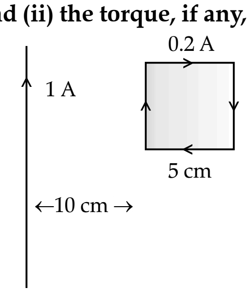
25. (a) Derive an expression for the induced emf developed when a coil of *N* turns, and area of cross-section *A*, is rotated at constant angular speed ω in a uniform magnetic field *B*.

(b) A wheel with 100 metallic spokes each 0.5 m long is rotated with a speed of 120 rev/min in a plane normal to the horizontal component of the Earth's magnetic field. If the resultant magnetic field at that place is 4 × 10⁻⁴ T and the angle of dip at the place is 30°, find the emf induced between the axle and the rim of the wheel. **5**

OR

(a) Derive the expression for the magnetic energy stored in an inductor when a current *I* develops in it. Hence, obtain the expression for the magnetic energy density.

(b) A square loop of sides 5 cm carrying a current of 0.2 A in the clockwise direction is placed at a distance of 10 cm from an infinitely long wire carrying a current of 1 A as shown. Calculate (i) the resultant magnetic force, and (ii) the torque, if any, acting on the loop.



5

Ans. Deriving expression for e.m.f. **3**

Finding induced e.m.f. between the axel and rim of wheel **2**

(a) Flux linked with the coil at any instant of time is :

$$\phi = NBA\cos\omega t$$

$$\frac{d\phi}{dt} = NB\omega(-\sin\omega t)$$

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

$$\varepsilon = NBA\sin\omega t$$

$$\varepsilon = \varepsilon_0\sin\omega t \qquad (Here\ \varepsilon_0 = NBA\omega)$$ ½

(b) $l = 0.5$ m, $\nu = 120$ rpm $= 2$ rps

$\omega = 2\pi\nu = 4\pi$ rad / s, $B = 4\times10^{-4}$T, $\delta = 30°$ ½

$$B_H = 4\times10^{-4}\times\frac{\sqrt{3}}{2}$$

$$B_H = 2\sqrt{3}\times10^{-4}\ \text{T}$$

$$\varepsilon = \frac{1}{2}B\omega l^2$$

$$\varepsilon = \frac{1}{2}\times2\sqrt{3}\times10^{-4}\times4\pi\times(0.5)^2$$

$$\varepsilon = 5.4\times10^{-4}\ \text{volt}$$ ½

[CBSE Marking Scheme, 2019]

OR

- **Deriving expression for magnetic energy stored in inductor and expression for energy density** **1½+½**
- **Calculating the resultant magnetic force and torque** **2½+½**

(a) When external source supplies current to the inductor, e.m.f. is induced in it due to self induction. So the external supply has to do work to establish current. The amount of work done is :

$$dW = |\varepsilon|Idt \qquad \left(\because \varepsilon = L\frac{dI}{dt}\right)$$

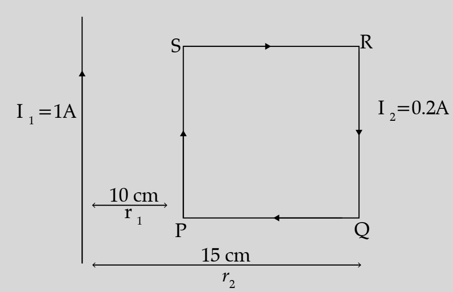
$$dW = LIdt$$

$$W = \frac{1}{2}LI^2$$

$$\text{Energy density} = \frac{\text{Energy}}{\text{Volume}}$$

$$U = \frac{\frac{1}{2}LI^2}{\text{Volume}}$$ ½

(b)



Force of attraction experienced by the length SP of the loop per unit length

$$f_1 = \frac{2\mu_0 I_1 I_2}{4\pi r_1}$$

$$f_1 = \frac{2\times10^{-7}\times1\times0.2}{10\times10^{-2}} = 4\times10^{-7}\,\text{Nm}^{-1}$$

Force is attractive.

$$f_2 = \frac{2\mu_0 I_1 I_2}{4\pi r_2}$$

$$f_2 = \frac{2\times10^{-7}\times1\times0.2}{15\times10^{-2}} = 2.6\times10^{-7}\,\text{Nm}^{-1}$$ ½

Force is repulsive.

So the net force experienced by the loop is (per unit length)

$f = (f_1 - f_2)$

Total force experienced by the loop is :

$F = (f_1 - f_2)l = (1.4 \times 10^{-7}) \times 5 \times 10^{-2}$ ½

Net force is attractive in nature. ½

As the lines of action of forces coincide torque is zero.

[CBSE Marking Scheme, 2019]

26. Explain, with the help of a diagram, how plane polarized light can be produced by scattering of light from the Sun.

Two polaroids P_1 and P_2 are placed with their pass axes perpendicular to each other. Unpolarised light of intensity I is incident on P_1. A third polaroid P_3 is kept between P_1 and P_2 such that its pass axis makes an angle of 45° with that of P_1. Calculate the intensity of light transmitted through P_1, P_2 and P_3. **5**

OR

(a) Why cannot the phenomenon of interference be observed by illuminating two pin holes with two sodium lamps?

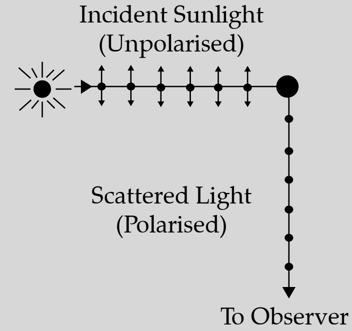
(b) Two monochromatic waves having displacements $y_1 = a\cos \omega t$ and $y_2 = a\cos (\omega t + f)$ from two coherent sources interfere to produce an interference pattern. Derive the expression for the resultant intensity and obtain the conditions for constructive and destructive interference.

(c) Two wavelengths of sodium light of 590 nm and 596 nm are used in turn to study the diffraction taking place at a single slit of aperture 2×10^{-6} m. If the distance between the slit and the screen is 1.5 m. Calculate the separation between the positions of the second maxima of diffraction pattern obtained in the two cases. **5**

Ans. Diagram production of polarized light by scattering of sun light **1**

- **Explanation** **1**
- **Calculation of intensity of light transmitted through P_1, P_2 and P_3** **½ +1+1½**

Diagram :



1

Explanation: Charges accelerating parallel to the double arrows do not radiate energy towards the observer. The radiation scattered by the molecules therefore is polarised perpendicular to the plane of the figure.

Alternatively: If the student writes " scattered light when viewed in a perpendicular direction is found to be polarised " **(Award one mark)**

Intensity of light transmitted by 1st Polaroid is,

$$I_1 = \frac{I}{2}$$ **1**

Intensity of light transmitted by 2nd Polaroid is,

$$I_2 = I_1\cos^2 45° = \frac{I}{2}\left(\frac{1}{\sqrt{2}}\right)^2 = \frac{I}{4}$$ ½

Intensity of light transmitted by 3rd Polaroid is, **1**

$$I_3 = I_1\cos^2 45° = \frac{I}{2}\left(\frac{1}{\sqrt{2}}\right)^2 = \frac{I}{8}$$ **1½**

[CBSE Marking Scheme, 2019

OR

- **Reason** ½
- **Deriving the expression for resultant intensity and condition for constructive and destructive interference** **1½+½+½**
- **Calculating the separation** **2**

(a) Because two independent sources cannot be coherent OR they are not coherent ½

(b) $y_1 = a\cos \omega t$

$y_2 = a\cos (\omega t + \phi)$

So resultant displacement is give by

$y = y_1 + y_2$

$y = a\cos \omega t + a\cos (\omega t + \phi)$

$y = 2a\cos (\phi/2) \cos(\omega t + \phi/2)$

The amplitude of the resultant displacement is $2a\cos(\phi/2)$and therefore intensity at that point will be $I = 4I_0 \cos^2 (\phi/2)$ **1**

For constructive interference:

$\phi = 0, \pm 2\pi, \pm 4\pi$,....... ½

For destructive interference:

$\phi = 0, \pm \pi, \pm 3\pi, \pm 5\pi$,....... ½

(c) Position of second maxima,

$$y_2 = \frac{5}{2}\frac{\lambda D}{a}$$ ½

Separation between the positions of the second maxima with λ_1 and λ_2 is: 1

$$\Delta y = \frac{5D(\lambda_2 - \lambda_1)}{2a}$$

$$= \frac{5 \times 1.5 \times (596 - 590) \times 10^{-9}}{2 \times 2 \times 10^{-6}}$$

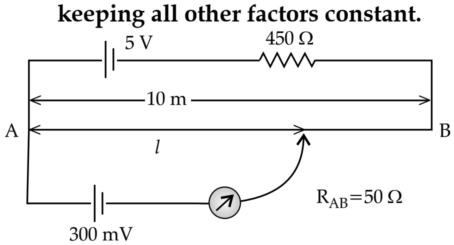
$$= 11.25 \times 10^{-3}\text{m}$$ 1

[CBSE Marking Scheme, 2019]

27. (a) Describe briefly, with the help of a circuit diagram, the method of measuring the internal resistance of a cell.

(b) Give reason why a potentiometer is preferred over a voltmeter for the measurement of emf of a cell.

(c) In the potentiometer circuit given below, calculate the balancing length *l*. Give reason, whether the circuit will work, if the driver cell of emf 5 V is replaced with a cell of 2 V, keeping all other factors constant. 5



OR

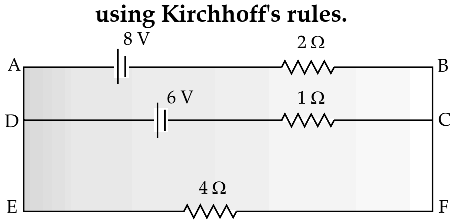
(a) State the working principle of a meter bridge used to measure an unknown resistance.

(b) Give reason

(i) Why the connections between the resistors in a metre bridge are made of thick copper strips,

(ii) Why is it generally preferred to obtain the balance length near the mid-point of the bridge wire.

(c) Calculate the potential difference across the 4 Ω resistor in the given electrical circuit, using Kirchhoff's rules.



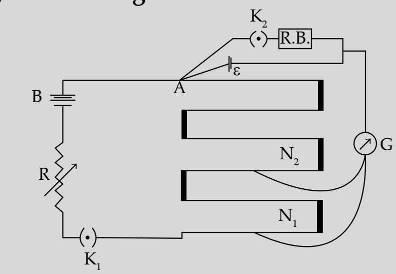
5

Ans. Circuit diagram and describing the method to measure internal resistance of cell by potentiometer **1+½**

Reason **1**

Calculating balancing length and reason (circuit works or not) **1½ +1**

(a) Circuit diagram :



1

Brief description: Plug in the key K_1 and keep K_2 unplugged and the find the balancing length l_1 such that : $E = Kl_1$

...1 ½

With the key K_2 also plugged in find out balancing length l_2 again such that :

$$V = Kl_2$$ **...2 ½**

$$r = \left(\frac{E}{V} - 1\right)R$$

$$r = \left(\frac{l_1}{l_2} - 1\right)R$$

(b) The potentiometer is preferred over the voltmeter for measurement of e.m.f. of a cell because potentiometer draws no current from the voltage source being measured. ½

(c) $V = 5\ V, R_{AB} = 50\ \Omega, R = 450\ \Omega$

$$I = \frac{5}{450 + 50} = \frac{1}{100} = 0.01\text{A}$$ ½

$$V_{AB} = 0.01 \times 50 = 0.5\text{ V}$$

$$K = \frac{0.5}{10} = 0.05\text{ Vm}^{-1}$$ ½

$$l = \frac{V}{K} = \frac{300 \times 10^{-3}}{0.05} = 6\text{m}$$ ½

With 2 V driver cell current in the circuit is

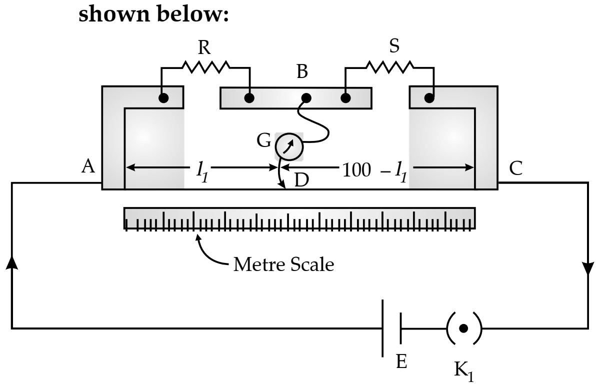
$$I = \frac{2}{450 + 50} = 0.04\text{A.}$$ ½

Potential difference across AB = 0.004 × 50 = 200 mV. Hence the circuit will not work. ½

[CBSE Marking Scheme, 2019]

OR

Ans. (a) The circuit diagram of the metre bridge is as shown below:

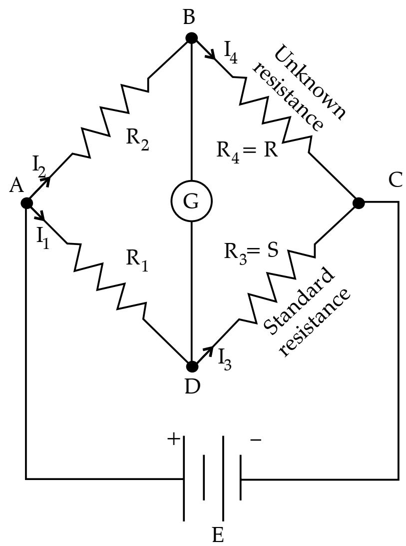


Working Principle: The working principle of the meter bridge is the same as that of a Wheatstone bridge. The Wheatstone bridge gets balanced when:

$$\frac{R_2}{R_1} = \frac{R_4}{R_3}$$ **1**

For the metre bridge, circuit shown above, this relation takes the form

$$\frac{R}{S} = \frac{l_1}{(100 - l_1)}$$ ½



Determination of unknown Resistance (*R*): In the circuit diagram shown above, *S* is taken as a known standard resistance.

We find the value of the balancing length l_1, corresponding to a given value of *S*. We then use the relation:

$$\frac{R}{S} = \frac{l_1}{(100 - l_1)}$$ ½

to calculate *R*.

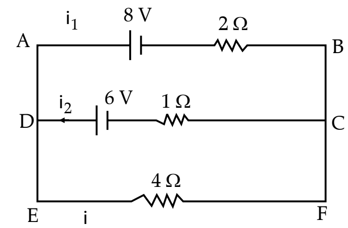
By choosing (at least three) different values of *S*, we calculate *R* each time. The average of these values of *R* gives the value of the unknown resistance.

(b) (i) This is to ensure that the connections do not contribute any extra, unknown, resistances in the circuit.

(ii) This is done to minimize the percentage error in the value of the unknown resistance.

Alternatively, This is done to have a better "balancing out" of the effects of any irregularity or non-uniformity in the metre bridge wire. **2**

(c) This can help in increasing the sensitivity of the metre bridge circuit.



Apply the current junction rule of Kirchhoff's Law at point D

$$i = i_1 + i_2 \quad ...(i)$$

Apply Kirchhoff's Voltage rule for the mesh AEFBA

$$4i + 2i_1 = 8$$

or $$2i + i_1 = 4 \quad ...(ii)$$

Apply Kirchhoff's voltage rule for mesh DEFCD

$$4i + 1i_2 = 6$$

or, $$4i + i_2 = 6 \quad ...(iii)$$

Adding equation (ii) and (iii), we get

$$6i + i_1 + i_2 = 10$$

or, $$6i + i = 10 \quad \text{[using equation (i)]}$$

or $$i = \frac{10}{7} \text{ A}$$

Now, the potential difference across resistor 4 Ω

$$V_{EF} = i \times 4$$

$$= \frac{10}{7} \times 4$$

$$= 5\frac{5}{7} \text{ V}$$ **1**

Outside Delhi Set -II 55/2/2

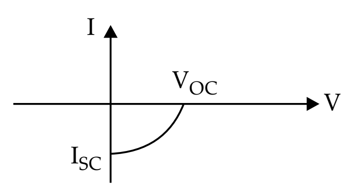
Note: Except these, all other questions are from Outside Delhi Set-I.

SECTION -A

1. Write the relation for the force acting on a charged particle *q* moving with velocity $\vec{v}$ in the presence of a magnetic field $\vec{B}$. 1

Ans. $\vec{f} = q(\vec{v} \times \vec{B})$. **[CBSE Marking Scheme, 2019] 1**

5. Identify the semiconductor diode whose I-V characteristics are as shown. 1



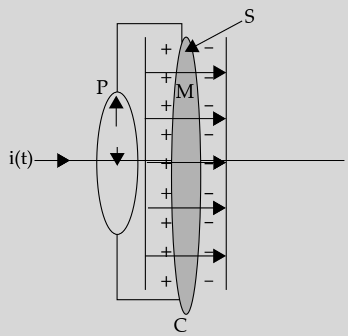
Ans. Solar Cell **[CBSE Marking Scheme, 2019] 1**

SECTION -B

7. How is the equation for Ampere's circuital law modified in the presence of displacement current? Explain. 2

Ans. Diagram **1**

Explanation **1**



½

$$\oint_{C_2} \vec{B}.\vec{dl} = \mu_0 I$$ ½

$$\oint_{C_2} \vec{B}.\vec{dl} = \mu_0 (I_C + I_D)$$ ½

There is an inconsistency in the Ampere's Circuital law.

Maxwell modified it to be

$$\oint \vec{B}.\vec{dl} = \mu_0 (i_C + i_d)$$

where $i_d = E_o \frac{d\phi_E}{dt}$ ½

[CBSE Marking Scheme, 2019]

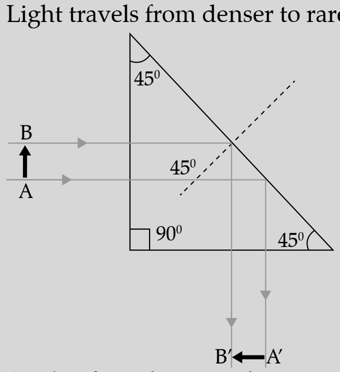
8. Under what conditions does the phenomenon of total internal reflection take place? Draw a ray diagram showing how a ray of light deviates by 90° after passing through a right-angled isosceles prism. **2**

Ans. Conditions ½+½

Diagram **1**

Conditions :

1. Light travels from denser to rarer medium ½



1

2. Angle of incidence in denser medium must be greater than critical angle. ½

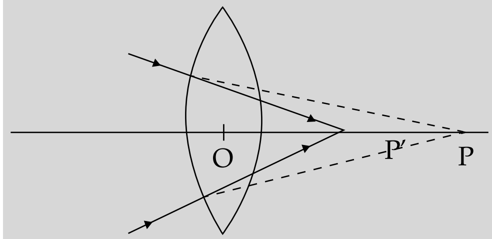
[CBSE Marking Scheme, 2019]

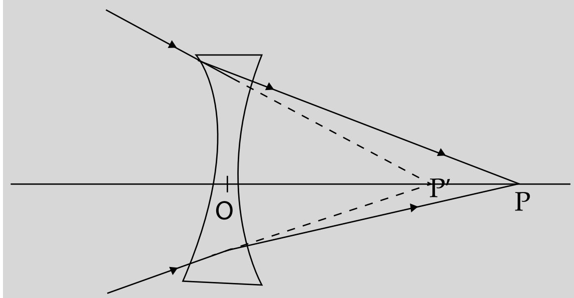
11. A beam of light converges at a point P. Draw ray diagrams to show where the beam will converge if (i) a convex lens, and (ii) a concave lens is kept in the path of the beam. **2**

Ans. Ray diagrams to show path of beam of light in case of

(i) Convex lens **1**

(ii) Concave lens **1**





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[CBSE Marking Scheme, 2019]

SECTION -C

14. (a) How is the stability of hydrogen atom in Bohr model explained by de-Broglie's hypothesis?

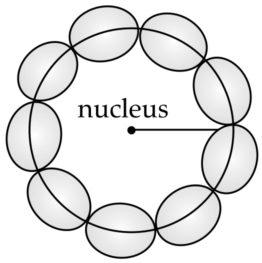
(b) A hydrogen atom initially in the ground state absorbs a photon which excites it to n = 4 level. When it gets de-excited, find the maximum number of lines which are emitted by the atom. Identify the series to which these lines belong. Which of them has the shortest wavelength? **3**

Ans.

(a) Bohr combined classical and early quantum concepts and gave his theory in the form of three postulates. The second postulates is.

Electron revolves around the nucleus only in those orbits for which angular momentum in integral multiple of $\frac{h}{2\neq}$.

de-Broglie had proposed that material particle such as electrons also have a wave nature. He argued that the electron in its circular orbit, as proposed by Bohr, must be seen as a particle wave. Drawing an analogy with waves travelling on the string, particle waves too can lead to formation of standing waves. In a string, standing waves are formed, when the total distance travelled by a wave back and forth is one wavelength, two wavelength or integral multiple of wavelengths. Other waves interfere with themselves after reflection and their amplitude falls to zero. For an electron moving in n^{th} orbit with radius r_n, its circumference is $2\pi r_n$



$\therefore \quad 2\pi r_n = n\lambda,\ n = 1, 2, 3$

From de-Broglie's hypothesis,

Wavelength of the election (λ) is given as

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

For n^{th} orbit, $\lambda = \dfrac{h}{mv_n}$

$$\therefore \quad 2\pi r_n = \frac{nh}{mv_n} \text{ or } mv_n r_n = \frac{nh}{2\neq}$$

This is the second postulate of Bohr. That give the discrete orbits and energy levels in hydrogen atom.

Thus de-Broglie explained the postulate of quantisation angular momentum. **2**

(b) For ground state $n = 1$ For de-excitation from $n = 4$ to $n = 1$ we get spectral lines constituting Lyman series whose wavelength is given by the formula,

$$\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{n^2}\right)$$

Here R = Rydberg constant number $n = 2, 3, 4$

$$\therefore \quad \frac{1}{\lambda_2} = R\left(1 - \frac{1}{4}\right) = \frac{3R}{4} \Rightarrow \lambda_2 = \frac{4}{3R}$$

$$\frac{1}{\lambda_3} = R\left(\frac{1}{1^2} - \frac{1}{3^2}\right) = R\left(1 - \frac{1}{9}\right)$$

$$\Rightarrow \quad \lambda_3 = \frac{9}{8R}$$

$$\frac{1}{\lambda_4} = R\left(\frac{1}{1^2} - \frac{1}{4^2}\right) = R\left(1 - \frac{1}{16}\right)$$

$$\Rightarrow \quad \lambda_4 = \frac{16}{15R} \qquad \left[\text{Here, } \frac{1}{R} = 912\text{Å}\right]$$

There would be maximum three lines emitted by the atom.

λ_4 has the shortest wavelength. **1**

16. What is the reason to operate photodiodes in reverse bias?

A *p-n* photodiode is fabricated from a semiconductor with a band gap of range of 2.5 to 2.8 eV. Calculate the range of wavelengths of the radiation which can be detected by the photodiode. 3

Ans. (a) Reason 1

(b) Formula ½

(c) Calculation of range of wave length.

½+½+½

Reason:

Under reverse bias change in current with the change in intensity of light is more significant. **1**

Calculation:

$$\lambda = \frac{hc}{E}$$

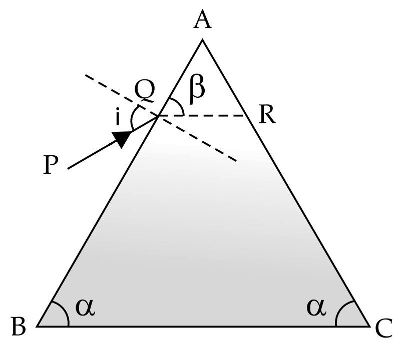
$$\lambda_1 = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{2.5 \times 1.6 \times 10^{-19}} = 497 \times 10^{-9}\text{ m}$$

$$\lambda_2 = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{2.5 \times 1.6 \times 10^{-19}} = 444 \times 10^{-9}\text{ m}$$

Range is 444×10^{-9} m *to* 497×10^{-9} m ½

[CBSE Marking Scheme, 2019]

18. A ray of light incident on the face AB of an isosceles triangular prism makes an angle of incidence (*i*) and deviates by angle β as shown in the figure. Show that in the position of minimum deviation ∠β = ∠α. Also find out the condition when the refracted ray QR suffers total internal reflection. 3



Ans. Proving α = β 2

Finding i_c 1

For minimum deviation,

$r_1 + r_2 = A; \quad r_1 = r_2$ **1**

$(90° - \beta) + (90° - \beta) = A$ ½

$180° - 2\beta = A$

$2\beta = 180° - A$

$2\beta = 2\alpha$

$\beta = \alpha$ ½

$r_1 + r_2 = A$

$r_1 + i_c = A$

$i_c = A - r_1$ ½

$i_c = A - (90° - \beta)$ ½

[CBSE Marking Scheme, 2019]

22. A 100 μF parallel plate capacitor having plate separation of 4 mm is charged by 200 V dc. The source is now disconnected. When the distance between the plates is doubled and at dielectric slab of thickness 4 mm and dielectric constant 5 is introduced between the plates, how will

(i) its capacitance,

(ii) the electric field between the plates, and

(iii) energy density of the capacitor get affected? Justify your answer in each case. **3**

Ans. (i) Change in Capacitance **1**

(ii) Change in Electric field **1**

(iii) Change in Energy density **1**

Dielectric slab of thickness 4 mm $= \frac{4}{5}$ mm

$= 0.8$mm

Effective (air) plate separation

$= (4+0.8)$ mm $= 4.8$mm

(i) Effective new capacitance

$$C' = 100\ \mu F \times \frac{4\ \text{mm}}{4.8\ \text{mm}} = \frac{400}{4.8}\mu F$$ ½

Change on capacitor remains same

$Q = C \times V = 100 \times 10^{-6} \times 200 = 2 \times 10^{-2}$C

$$\text{New p.d.} V' = \frac{Q}{C'} = \frac{2 \times 10^{-2} \times 4.8 \times 10^{-6}}{400}$$

$$= 2.4 \times 10^{-6}\ \text{volt}$$ ½

(ii) Effective new Electric Field,

$$E' = \frac{2.4 \times 10^{-10}}{4.8 \times 10^{-3}}$$

$$= 5 \times 10^{-8}\ \text{Vm}^{-1}$$ **1**

(iii) $$\frac{\text{New energy stored}}{\text{Original energy stored}} = \frac{\frac{1}{2}C'V^2}{\frac{1}{2}CV^2}$$

$$\frac{C'}{C} = \frac{400}{4.8 \times 100} = 0.8$$

New energy density will be (0.8) of the original density. **1**

[CBSE Marking Scheme, 2019]

❑❑