SAMPLE QUESTION PAPER

BLUE PRINT

Time Allowed : 3 hours **Maximum Marks :** 70

S. No.	Chapter	VSA/ AR/ Case Based (1 mark)	SA-I (2 marks)	SA-II (3 marks)	LA (5 marks)	Total
1.	Electrostatics	3(3)	2(4)	1(3)	–	**8(16)**
2.	Current Electricity	1(1)	–	–	1(5)	
3.	Magnetic Effects of Current and Magnetism	2(5)	–	1(3)		**7(17)**
4.	Electromagnetic Induction and Alternating Current	2(2)	1(2)	–	1(5)	
5.	Electromagnetic Waves	2(2)	1(2)	1(3)	–	**9(18)**
6.	Optics	3(6)	1(2)	1(3)	–	
7.	Dual Nature of Radiation and Matter	1(1)	1(2)	–	–	**6(12)**
8.	Atoms and Nuclei	2(2)	1(2)	–	1(5)	
9.	Electronic Devices	–	2(4)	1(3)	–	**3(7)**
	Total	**16(22)**	**9(18)**	**5(15)**	**3(15)**	**33(70)**

Subject Code : **042**

PHYSICS

Time allowed : 3 hours ***Maximum marks : 70***

(i) All questions are compulsory. There are 33 questions in all.

(ii) This question paper has five sections: Section A, Section B, Section C, Section D and Section E.

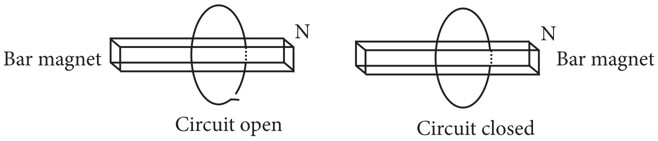
(iii) Section A contains ten very short answer questions and four assertion reasoning MCQs of 1 mark each. Section B has two case based questions of 4 marks each, Section C contains nine short answer questions of 2 marks each, Section D contains five short answer questions of 3 marks each and Section E contains three long answer questions of 5 marks each.

(iv) There is no overall choice. However internal choice is provided. You have to attempt only one of the choices in such questions.

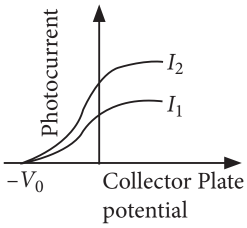
SECTION - A

All questions are compulsory. In case of internal choices, attempt any one of them.

1. Consider a magnet surrounded by a wire with an on/off switch *S* (figure). If the switch is thrown from the off position (open circuit) to the on position (closed circuit), will a current flow in the circuit? Explain.



2. From the given graph of photocurrent against collector plate potential, for two different intensities of light I_1 and I_2,. What is the relationship between photocurrents to the corresponding intensities ?



OR

The wavelength of electromagnetic radiation is doubled. What will happen to the energy of photon?

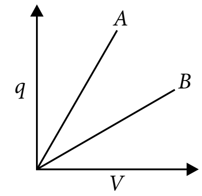
3. How is the radius of a nucleus related to its mass number *A*?

4. In hydrogen atom, if the electron is replaced by a particle which is 200 times heavier but has the same charge, how would its radius change ?

5. Equipotentials at a great distance from a collection of charges whose total sum is not zero are approximately

OR

The given graph shows variation of charge 'q' versus potential difference 'V' for two capacitors C_1 and C_2. Both the capacitors have same plate separation but plate area of C_2 is greater than that of C_1. Which line (A or B) corresponds to C_1 and why?



6. Two large conducting spheres carrying charges Q_1 and Q_2 are brought close to each other. Is the magnitude of electrostatic force between them exactly given by $\frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$, where r is the distance between their centres?

7. What causes refraction of light?

8. The electric field intensity produced by the radiations coming from 100 W bulb at a 3 m distance is E. Find the electric field intensity produced by the radiations coming from 50 W bulb at the same distance

OR

Give one use of : Ultraviolet rays

9. A wire of resistance 4 Ω is used to wind a coil of radius 7 cm. The wire has a diameter of 1.4 mm and the specific resistance of its material is 2×10^{-7} Ω m. Calculate the number of turns in the coil.

10. Why is the use of ac voltage preferred over dc voltage? Give two reasons.

OR

The peak value of emf in ac is E_0. Write its (i) rms (ii) average value over a complete cycle.

For question numbers 11, 12, 13 and 14, two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false and R is also false

11. Assertion (A) : Lines of force are perpendicular to conductor surface.

Reason (R) : Generally electric field is perpendicular to equipotential surface.

12. Assertion (A) : If current is flowing through a machine of iron eddy currents are produced.

Reason (R) : Change in magnetic flux through an area causes eddy currents.

13. Assertion (A) : Goggles have zero power.

Reason (R): Radius of curvature of both sides of lens is same.

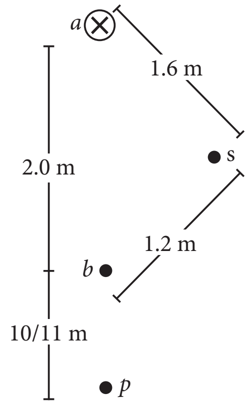
14. Assertion (A) : In electromagnetic waves electric field and magnetic field lines are perpendicular to each other.

Reason (R): Electric field and magnetic field are self sustaining.

SECTION - B

Questions 15 and 16 are Case Study based questions and are compulsory. Attempt any 4 sub parts from each question. Each question carries 1 mark.

15. Two long straight parallel wires are 2 m apart, perpendicular to the plane of the paper. The wire *A* carries a current of 9.6 A, directed into the plane of the paper. The wire *B* carries a current such that the magnetic field of induction at the point *P*, at 10/11 m from the wire *B*, is zero.



(i) If the two conductors carry current in opposite directions there will be
- (a) force of attraction between the two conductors
- (b) force of repulsion between the two conductors
- (c) no force between them
- (d) none of these.

(ii) Find the magnitude of the current in *B*.

(a) 2 A (b) 2.5 A (c) 3 A (d) 3.5 A

(iii) Find the magnitude of the magnetic field of induction of the point *S*.

(a) 2.4×10^{-6} T (b) 2.4×10^{-5} T (c) 1.3×10^{-6} T (d) 1.3×10^{-5} T

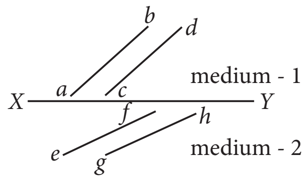
(iv) Find the force per unit length on the wire *B*.

(a) 2.4×10^{-6} N (b) 3.4×10^{-6} N (c) 3.4×10^{-6} N (d) 2.9×10^{-6} N

(v) The force experienced by 10 cm of wire A due to wire *B* is

(a) 2.9×10^{-6} N (b) 3.2×10^{-6} N (c) 2.9×10^{-7} N (d) 3.2×10^{-7} N

16. The figure shows a surface *XY* separating two transparent media, medium-1 and medium-2. The lines *ab* and *cd* represent wavefronts of a light wave travelling in medium- 1 and incident on *XY*. The lines *ef* and *gh* represent wavefronts of the light wave in medium-2 after refraction.



(i) Light travels as a
- (a) parallel beam in each medium
- (b) convergent beam in each medium
- (c) divergent beam in each medium
- (d) divergent beam in one medium and convergent beam in the other medium.

(ii) The phases of the light wave at *c*, *d*, *e* and *f* are ϕ_C, ϕ_d, ϕ_e and ϕ_f respectively. It is given that $\phi_c \neq \phi_f$

(a) ϕ_c cannot be equal to ϕ_d
(b) ϕ_d can be equal to ϕ_e
(c) $(\phi_d - \phi_f)$is equal to $(\phi_c - \phi_e)$
(d) $(\phi_d - \phi_c)$ is not equal to $(\phi_f - \phi_e)$

(iii) Speed of light is

(a) same in medium-1 and medium-2
(b) larger in medium-1 than in medium-2
(c) larger in medium-2 than in medium-1
(d) different at *b* and *d*.

(iv) What is the shape of a wavefront emitted by a light source in the form of a narrow slit?

(a) Spherical (b) Cylindrical (c) Plane (d) Oval

(v) A plane wave passes through a convex lens. The geometrical shape of the wavefront that emerges is

(a) plane
(b) diverging spherical
(c) converging spherical
(d) none of these.

SECTION - C

All questions are compulsory. In case of internal choices, attempt anyone.

17. Define electric flux. Write its SI unit. A charge *q* is enclosed by a spherical surface of radius *R*. If the radius is reduced to half, how would the electric flux through the surface change ?

18. Find the disintegration energy *Q* for the fission event represented by equation

$$_{92}U^{235} + {}_0n^1 \rightarrow {}_{92}U^{236} \rightarrow {}^{140}_{58}Ce + {}^{90}_{40}Zr + {}_0n^1$$

If mass of $_{92}U^{235}$ = 235.0439 u, $_0n^1$ = 1.00867u, $^{140}_{58}Ce$ = 139.9054 u and $^{90}_{40}Zr$ = 93.9063 u, find energy released in the process.

OR

The nucleus $^{235}_{92}Y$, initially at rest, decays into $^{231}_{90}X$ by emitting an α-particle

$$^{235}_{92}Y \longrightarrow {}^{231}_{90}X + {}^4_2He + \text{energy.}$$

The binding energies per nucleon of the parent nucleus, the daughter nucleus and α-particle are 7.8 MeV, 7.835 MeV and 7.07 MeV, respectively. Assuming the daughter nucleus to be formed in the unexcited state and neglecting its share in the energy of the reaction, find the speed of the emitted α-particle. (Mass of α-particle $= 6.68 \times 10^{-27}$ kg)

19. An ac input signal of frequency 60 Hz, is rectified by a (i) half wave rectifier, (ii) full wave rectifier. Draw the output waveform and write the output frequency in each case.

OR

Plot of graph showing variation of current versus voltage for the material GaA.

20. **(a)** What meaning would you give to the capacitance of a single conductor?
(b) Guess a possible reason why water has a much greater dielectric constant (= 80) then say, mica (= 6).
(c) A sensitive instrument is to be shielded from the strong electrostatic fields in its environment. Suggest a possible way.

21. **(a)** Show graphically, the variation of the de-Broglie wavelength (λ) with the potential (V) through which an electron is accelerated from rest.
(b) Write the relationship of de-Broglie wavelength λ associated with a particle of mass *m* in terms of its kinetic energy *E*.

22. Gamma rays and radio waves travel with the same velocity in free space. Distinguish between them in terms of their origin and the main application.

23. How does the mutual inductance of a pair of coils change when

(a) the distance between the coils is increased?

(b) the number of turns in each coil is decreased?

Justify your answer in each case.

OR

Current in circuit falls from 5.0 A to 0.0 A in 0.1s. If an average emf of 200 V induced, give an estimate of the self-inductance of the circuit.

24. **(a)** Write the necessary conditions for the phenomenon of total internal reflection to occur.

(b) Write the relation between the refractive index and critical angle for a given pair of optical media.

25. Distinguish between 'intrinsic' and 'extrinsic' semiconductors.

SECTION - D

All questions are compulsory. In case of internal choices, attempt any one.

26. Use the lens equation to deduce algebraically:

(a) An object placed within the focus of a convex lens produces a virtual and enlarged image.

(b) A concave lens produces a virtual and diminished image independent of the location of the object.

27. **(a)** Suggest reasons, why (i) food in metal containers cannot be cooked in a microwave oven, (ii) an empty glass container does not get hot in microwave oven?

(b) What is the frequency of electromagnetic waves produced by oscillating charge of frequency υ?

OR

Write two applications each of (a) microwaves, (b) infra-red waves, and (c) radio waves.

28. A magnetising field of 1500 A m^{-1} produces a flux of 2.4×10^{-5} weber in a bar of iron of cross-sectional area 0.5 cm^2. Calculate the permeability and susceptibility of the iron bar used.

29. Draw *V-I* characteristics of a *p-n* junction diode. Answer the following questions, giving reasons.

(i) Why is the current under reverse bias almost independent of the applied potential upto a critical voltage?

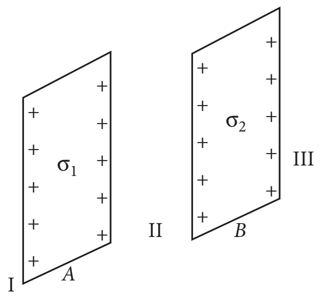
(ii) Why does the reverse current show a sudden increase at the critical voltage?

(iii) Name any semiconductor device which operates under the reverse bias in the breakdown region.

OR

With what considerations in view is a photodiode fabricated? Explain its working with the help of a suitable diagram. With the help of *V-I* characteristics, state how photodiode is used to detect optical signals.

30. Two infinitely large plane thin parallel sheets having surface charge densities σ_1 and σ_2 ($\sigma_1 > \sigma_2$) are shown in the figure. Write the magnitudes and directions of the net electric fields in the regions marked II and III.



SECTION - E

All questions are compulsory. In case of internal choices, attempt any one.

31. With the help of a labelled diagram, explain the working of a step-up transformer. Give reasons to explain the following :

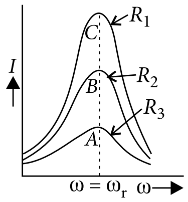
(i) The core of the transformer is laminated.

(ii) Thick copper wire is used in windings.

OR

What do you understand by 'sharpness of resonance' for a series *LCR* resonant circuit ?

How is it related with the quality factor '*Q*' of the circuit? Using the graphs given in the diagram, explain the factors which affect it. For which graph is the resistance (*R*) minimum?



32. (a) Consider a gas consisting Li^{2+} (which is hydrogen like ion)

(i) Find the wavelength of radiation required to excite the electron in Li^{++} from $n = 1$ and $n = 3$.

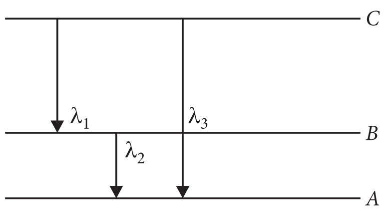
(ii) How many spectral lines are observed in the emission spectrum of the above excited system?

(b) A hydrogen like atom (atomic number *Z*) is in a higher excited state of quantum number *n*. This excited atom can make a transition to the first excited state by successively emitting two photons of energies 10.20 eV and 17.00 eV respectively. Alternatively, the atom from the same excited state can make a transition to the second excited state by successively emitting two photons of energies 4.25 eV and 5.95 eV respectively. Determine the values of *n* and *Z*. (Ionisation energy of hydrogen atom = 13.6 eV)

OR

(i) State Bohr's quantization condition for defining stationary orbits. How does de-Broglie hypothesis explain the stationary orbits ?

(ii) Find the relation between the three wavelengths λ_1, λ_2 and λ_3 from the energy level diagram shown in the figure.



33. Draw the circuit diagram of potentiometer which can be used to determine the internal resistance (*r*) of a given cell of emf (ε). With the help of this diagram describe the method to find the internal resistance of the primary cell.

OR

A cell of unknown emf ε and internal resistance *r*, two unknown resistances R_1 and $R_2 (R_2 > R_1)$ and a perfect ammeter are given. The current in the circuit is measured in five different situations:

(a) Without any external resistance in the circuit,

(b) With resistance R_1 only,

(c) With resistance R_2 only,

(d) With both R_1 and R_2 used in series combination,

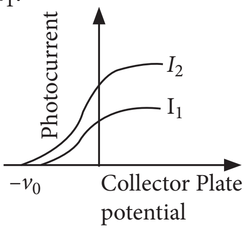
(e) With both R_1 and R_2 used in parallel combination.

The current obtained in the five cases are 0.42 A, 0.6 A, 1.05 A, 1.4 A and 4.2 A, but not necessarily in that order. Identify the currents in the five cases listed above and calculate ε, *r*, R_1 and R_2.

SOLUTIONS

1. No part of wire is moving, so motional emf is zero. Also magnetic field is not changing with time so no emf will induce, therefore no current flows in circuit.

2. For a given frequency of incident radiation, the photocurrent is directly proportional to the intensity of light *i.e.*, $I_2 > I_1$.



OR

$E \propto \frac{1}{\lambda}$, so when λ is doubled, energy of photons becomes halved.

3. The volume of the nucleus is directly proportional to the number of nucleons (mass number) constituting the nucleus.

$\frac{4}{3}\pi R^3 \propto A$ where $R \to$ radius

$R \propto A^{1/3}$, $A \to$ Mass number

$R = R_0 A^{1/3}$

4. Radius of n^{th} orbit of H-atom with electron is

$$r = \frac{n^2h^2\varepsilon_0}{\pi me^2} \quad \text{or} \quad r \propto \frac{1}{m}$$

So, if electron is replaced with a charged particle of same charge but of mass 200 m, then radius of n^{th} orbit of H-atom will become

$$\frac{r'}{r} = \frac{m}{200m} = \frac{1}{200} \quad \text{or} \quad r' = \frac{r}{200}$$

i.e., will reduce to $\frac{r}{200}$ times that with electron.

5. Collection of charges whose total sum is not zero can be considered as a point charge from a great distance. So, equipotentials should be spheres.

OR

The plate area of C_2 is greater than that of C_1. Since capacitance of a capacitor is directly proportional to the area of the plates,

$\therefore \quad C_2 > C_1$

Now, $C = \frac{q}{V}$

Therefore, slope of a line $(=q/V)$ is directly proportional to the capacitance of the capacitor, it represents. Since the slope of line A is more than that of B, line A represents C_2 and the line B represents C_1.

6. No, because coulomb's law holds good only for point charges.

7. Light travels with different speeds in different refracting medium which causes refraction.

8. Electric field intensity on a surface due the incident radiation is

$$E = \frac{U}{At} = \frac{P}{A} \quad \left(\because \frac{U}{t} = P\right)$$

$\therefore \quad E \propto P$ (for the given area of the surface)

$$\therefore \quad \frac{E'}{E} = \frac{P'}{P} = \frac{50}{100} = \frac{1}{2}$$

$$E' = \frac{E}{2}$$

OR

Ultraviolet rays : These are used to destroy the bacteria and for sterilizing surgical instruments.

9. Let n be the number of turns in the coil.

Then total length of wire used,

$l = 2\pi r \times n = 2\pi \times 7 \times 10^{-2} \times n$

Total resistance, $R = \rho \frac{l}{A}$

or $\quad 4 = \frac{2\times10^{-7}\times2\pi\times7\times10^{-2}\times n}{\pi(0.7\times10^{-3})^2} \quad \therefore \quad n = 70$

10. (i) AC can be transmitted with much lower energy losses as compared to dc.

(ii) AC voltage can be adjusted (stepped up or stepped down) as per requirement.

OR

E_0 = peak value of emf

(i) rms value $[E_{rms}] = \frac{E_0}{\sqrt{2}}$

(ii) average value $[E_{av}]$ = zero

11. **(a)**

12. **(d) :** Eddy currents are produced when a metal sheet is placed in a changing magnetic field. In the metal sheet, we can consider closed loops through which an induced current flows due to a change of magnetic flux. This current is called eddy current and it gives rise to loss of thermal energy.

13. (a) : Goggles have zero power.
The focal length is given by

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

For goggle lenses, both sides are curved the same way. R_1 and R_2 are positive. If they are the same, $\frac{1}{f} = 0$ *i.e.,* power is zero.

14. (b) : Electromagnetic waves are those waves in which there are sinusoidal variation of electric and magnetic field vectors at right angles to each other as well as at right angles to the direction of wave propagation. They are self-sustaining oscillations of electric and magnetic fields in free space or vacuum.

15. (i)(b)
(ii) (c) : The magnitudes of these fields should be equal so that

$$\frac{\mu_0(9\cdot 6A)}{2\pi\left(2+\frac{10}{11}\right)m} = \frac{\mu_0 i}{2\pi\left(\frac{10}{11}\right)m}$$

or $i = 3.0$ A.
(iii) (c) : $(ab)^2 = 4\ m^2$
$(as)^2 = 2.56\ m^2$
and $(bs)^2 = 1.44\ m^2$
so that $(ab)^2 = (as)^2 + (bs)^2$ and angle $asb = 90°$
The field at s due to the wire a

$$= \frac{\mu_0(9\cdot 6\ A)}{2\pi\times 1\cdot 6\ m} = \frac{\mu_0}{2\pi}\times 6\ A\ m^{-1}$$

and that due to the wire b

$$= \frac{\mu_0}{1\cdot 2\ m}\frac{3A}{} = \frac{\mu_0}{2\pi}\times 2\cdot 5\ A\ m^{-1}$$

These fields are at 90° to each other so that their resultant will have a magnitude.

$$\sqrt{\left(\frac{\mu_0}{2\pi}\times 6\ A\ m^{-1}\right)+\left(\frac{\mu_0}{2\pi}\times 2\cdot 5\ A\ m^{-3}\right)^2}$$

$$= \frac{\mu_0}{2\pi}\sqrt{36+6\cdot 25}\ A\ m^{-3}$$

$= 2 \times 10^{-2}$ T mA^{-1} $\times$ 6.5 A m^{-1}
$= 1.3 \times 10^{-9}$ T
(iv) (d): The force per unit length on the wire b

$$= \frac{\mu_0 i_1 i_2}{2\pi d} = (2\times 10^{-7}\text{T m A}^{-1})\times\frac{(9\cdot 6\ A)(3A)}{2\cdot 0\ m}$$

$= 2.9 \times 10^{-8}$ N.
(v) (c) : Force, $F = Bil$

$$= \frac{\mu_0 i_A i_B}{2\pi D} l = 2.9\times 10^{-6}\times 10\times 10^{-2}$$

$= 2.9 \times 10^{-7}$ N

16. (i)(a): Since the path difference between two waveform is equal, light traves as parallel bean in each medium.
(ii) (c) : Since all points on the wavefront are in the same phase,
$\phi_d = \phi_c$ and $\phi_f = \phi_e$
$\therefore\ \phi_d - \phi_f = \phi_c - \phi_e$.
(iii) (b): The gap between consecutive wavefront in medium-2 is less than that in medium. Therefore, wavelength of light in medium 2 is less.
Since $v = \nu\lambda$
Speed of light in medium 2 is smaller.
(iv) (b)
(v) (c)

17. Electric flux over an area in an electric field represents the total number of electric lines crossing this area. SI unit of electric flux is N m^2 C^{-1}.
When the radius, R is reduced to half, electric flux through the surface remains the same. This is because electric flux through the surface depends only on charge enclosed.

18. The mass lost in the process,
Δm = 235.0439 – (139.9054 + 93.9063 + 1.00867)
= 0.22353 u
The corresponding energy released = Δmc^2
= $(0.22353)(3 \times 10^8)^2$ J = 208 MeV

OR

Given ${}^{235}_{92}Y \rightarrow {}^{231}_{90}X + {}^{4}_{2}\text{He} + \text{energy}$
Since share of energy of daughter nucleus can be neglected, K.E. of α particle,

$$= \left(\frac{A-4}{A}\right)Q$$

Now, $Q = (231 \times 7.835 + 4 \times 7.07) - 235 \times 7.8$
$= 5.165$ MeV

19.

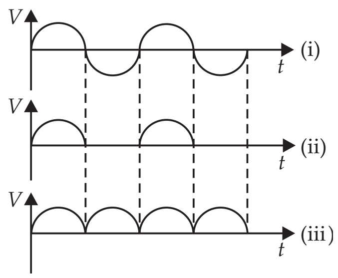
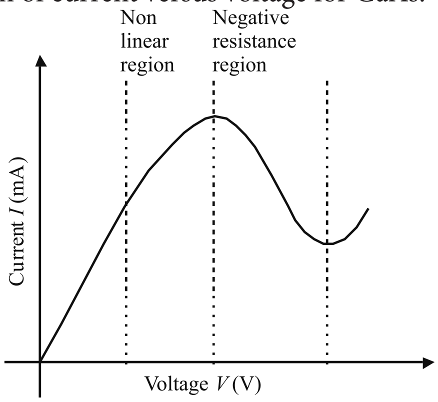


Figure (i) shows input waveform.
Figure (ii) shows output waveform for half wave rectifier.
Figure (iii) shows output waveform for full wave rectifier.
(i) Output frequency for half wave rectification = 60 Hz
(ii) Output frequency for full wave rectification = 120 Hz.

OR

Variation of current versus voltage for GaAs.

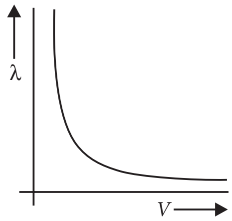


20. **(a)** It means that a single conductor is a capacitor whose other plate can be considered to be at infinity.

(b) A water molecule is a polar molecule with non-zero electric dipole moment, however mica does not have polar molecules. So, dielectric constant of water is high.

(c) As we found that electric field inside the cavity of conductor is zero, even on charging the conductor, so the sensitive instrument can be shielded from the strong electrostatic fields in its environment, by covering it with a metallic cover.

21. **(a)** $\lambda = \frac{12.27}{\sqrt{V}}$ Å



$\lambda^2 V = \text{constant}$

(b) $\lambda = \frac{h}{\sqrt{2mE}}$

22. Gamma rays : These rays are of nuclear origin and are produced in the disintegration of radioactive atomic nuclei and in the decay of certain subatomic particles. They are used in the treatment of cancer and tumours.

Radio waves : These waves are produced by the accelerated motion of charges in conducting wires or oscillating electric circuits having inductor and capacitor. These are used in satellite, radio and television communication

23. (a)Mutual inductance between the coils is decreased. Due to increase in distance, magnetic field produced by one coil at the other decreases, thereby decreasing magnetic flux linked with second coil and hence decreasing mutual inductance between them.

(b) As $M = \frac{\mu_0 N_1 N_2 A}{l}$, so on decreasing number of turns N_1 and N_2 in each coil, mutual inductance between them decreases.

OR

Let 'L' is the coefficient of self inductance, the back emf

$$\varepsilon = -L\frac{dI}{dt}$$

$$200 = -L\frac{(I_f - I_i)}{t} \quad \text{or} \quad 200 = -L\frac{(0-5)}{0.1}$$

$L = 4$ H.

24. **(a)** Essential conditions for total internal reflection :

(i) Light should travel from a denser medium to a rarer medium.

(ii) Angle of incidence in denser medium should be greater than the critical angle for the pair of media in contact.

(b) ${}^a\mu_b = \frac{1}{\sin C}$, where a and b are the rarer and denser media respectively and C is the critical angle for the given pair of optical media.

25.

	Intrinsic Semiconductors	Extrinsic Semiconductors
(i)	These are pure semiconducting tetravalent crystals.	These are semi-conducting tetravalent crystals doped with impurity atoms of group III or V.
(ii)	Their electrical conductivity is low.	Their electrical conductivity is high.
(iii)	There is no permitted energy state between valence and conduction bands.	There is permitted energy state of the impurity atom between valence and conduction bands.

26. (a)For convex lens : f is +ve and u is – ve.

For $0 < |u| < f$,

$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{f} - \frac{1}{|u|} = \frac{|u| - f}{f|u|} = -\text{ve}$$

or $v = -\text{ve}$

$$m = v/u, \quad \text{As } \frac{1}{|v|} < \frac{1}{|u|} \quad \text{or} \quad |v| > |u|$$

So $m > 1$

and hence image formed is enlarged.

(b) For concave lens : f is –ve and u is –ve
For $u < 0$ (object is on left)

$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = -\left[\frac{1}{|f|} + \frac{1}{|u|}\right] = -\left[\frac{|f|+|u|}{|f|\cdot|u|}\right]$$

or $v = -\text{ve}$

As v is –ve, so image lies on the left of lens and is virtual in nature.

$$m = \frac{v}{u}, \quad \text{As } \frac{1}{|v|} > \frac{1}{|u|} \quad \text{or} \quad |v| < |u|$$

So $m < 1$, and hence image formed is diminished.

27. (a) In a microwave oven, the frequency of microwaves is selected to match the resonance frequency of water molecules, so that the energy from the waves is transferred efficiently to the kinetic energy of the molecules. This raises the temperature of any food containing water.

(i) One should not use metal containers in a microwave oven because of the danger of getting a shock from accumulated electric charges. Metals may also melt from heating.

(ii) The molecules of the glass container do not respond to the frequency of microwaves. Due to this, energy from the microwaves is not transferred to the glass container and hence it does not get hot in a microwave oven.

(b) Frequency of the electromagnetic wave produced will be equal to the frequency υ of oscillating charge.

OR

(a) Microwave :
   (i) Are used in radar system for aircraft.
   (ii) In microwave ovens.

(b) Infra red waves :
   (i) Infrared lamps are used in physical therapy.
   (ii) For producing dehydrated fruits.

(c) Radio waves :
   (i) Are used in television communication (100 MHz to 200 MHz).
   (ii) In cellular mobile radio (896 MHz – 935 MHz)

28. Here, $H = 1500 \text{ A m}^{-1}$, $\phi = 2.4 \times 10^{-5}$ weber
$A = 0.5 \text{ cm}^2 = 0.5 \times 10^{-4} \text{ m}^2$

$$B = \frac{\phi}{A} = \frac{2.4 \times 10^{-5}}{0.5 \times 10^{-4}} = 4.8 \times 10^{-1} \text{ T}$$

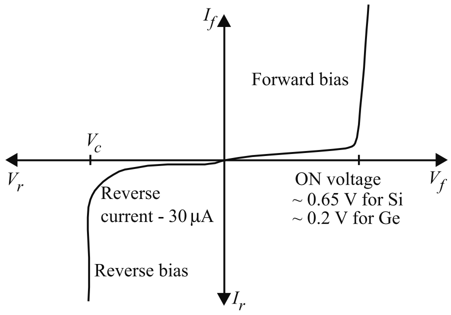
$$\mu = \frac{B}{H} = \frac{4.8 \times 10^{-1}}{1500} = 3.2 \times 10^{-4}$$

$$\mu_r = \frac{\mu}{\mu_0} = \frac{3.2 \times 10^{-4}}{4\pi \times 10^{-7}} = 0.255 \times 10^3 = 255$$

As $\mu_r = 1 + \chi_m$

$\therefore \quad \chi_m = \mu_r - 1 = 255 - 1 = 254$

29.



(i) The reverse current is due to minority charge carriers and even a small voltage is sufficient to sweep the minority carriers from one side of the junction to the other side of the junction.

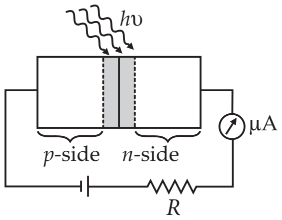
(ii) At critical voltage/breakdown voltage, a large number of covalent bonds break, resulting in availability of large number of charge carriers.

(iii) Zener diode device operates under the reverse bias in the breakdown region.

OR

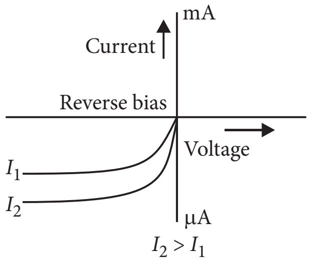
(i) A photodiode is fabricated by allowing light to fall on a diode through a transparent window. It is fabricated such that the generation of e-h pairs take place near the depletion region.

(ii) Working of photodiode : A junction diode made from light sensitive semiconductor is called a photodiode. A photodiode is a p-n junction diode arranged in reverse biasing.

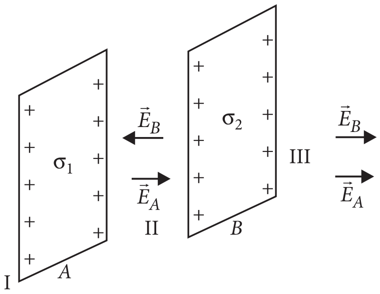


The number of charge carriers increases when light of suitable frequency is made to fall on the p-n junction, because new electron holes pairs are created by absorbing the photons of suitable frequency. Intensity of light controls the number of charge carriers. Due to this property photodiodes are used to detect optical signals.

V-I characteristics :



30.



In region II :

The electric field due to the sheet of charge A will be from left to right (along the positive direction) and that due to the sheet of charge B will be from right to left (along the negative direction). Therefore, in region II, we have

$$E = \frac{\sigma_1}{\varepsilon_0} + \left(-\frac{\sigma_2}{\varepsilon_0}\right)$$

$\vec{E} = \frac{1}{\varepsilon_0}(\sigma_1 - \sigma_2)$ along positive direction

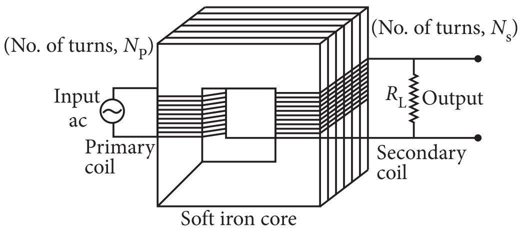
In region III :

The electric fields due to both the charged sheets will be from left to right, *i.e.*, along the positive direction. Therefore, in region III, we have

$$E = \frac{\sigma_1}{\varepsilon_0} + \frac{\sigma_2}{\varepsilon_0}$$

$\vec{E} = \frac{1}{\varepsilon_0}(\sigma_1 + \sigma_2)$ along positive direction

31. Step-up transformer (or transformer) is based on the principle of mutual induction.



An alternating potential (V_p) when applied to the primary coil induced an emf in it.

$$\varepsilon_p = -N_p \frac{d\phi}{dt}$$

If resistance of primary coil is low $V_p = \varepsilon_p$.

i.e., $V_p = -N_p \frac{d\phi}{dt}$

As same flux is linked with the secondary coil with the help of soft iron core due to mutual induction, emf is induced in it.

$$\varepsilon_s = -N_s \frac{d\phi}{dt}$$

If output circuit is open $V_s = \varepsilon_s$

$$V_s = -N_s \frac{d\phi}{dt}$$

Thus $\frac{V_s}{V_p} = \frac{N_s}{N_p}$

For an ideal transformer, $P_{out} = P_{in}$

$\Rightarrow \quad I_s V_s = I_p V_p$

$\therefore \quad \frac{V_s}{V_p} = \frac{I_p}{I_s} = \frac{N_s}{N_p}$

For step-up transformer $\frac{N_s}{N_p} > 1$

In case of dc voltage, flux does not change. Thus no emf is induced in the circuit.

(i) The core of the transformer is laminated to reduce eddy current losses.

(ii) Thick copper wire is used in voindings of transformers because of its low resistivity i.e., low resistance.

OR

(a) Sharpness of resonance : It is defined as the ratio of the voltage developed across the inductance (L) or capacitance (C) at resonance to the voltage developed across the resistance (R).

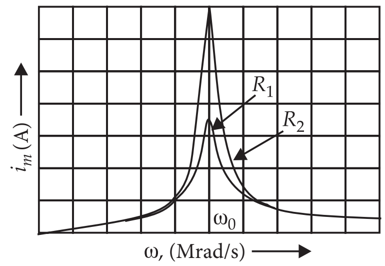
$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

It may also be defined as the ratio of resonant angular frequency to the bandwidth of the circuit.

$$Q = \frac{\omega_r}{2\Delta\omega}$$

Circuit become more selective if the resonance is more sharp, maximum current is more, the circuit is close to resonance for smaller range of ($2\Delta\omega$) of frequencies. Thus, the tuning of the circuit will be good.

Figure shows the variation of i_m with ω in a LCR series circuit for two values of resistance R_1 and $R_2 (R_1 > R_2)$,



The condition for resonance in the LCR circuit is,

$$X_L = X_C \Rightarrow \omega_0 L = \frac{1}{\omega_0 C} \Rightarrow \omega_0 = \frac{1}{\sqrt{LC}}$$

We see that the current amplitude is maximum at the resonant frequency. Since $i_m = V_m / R$ at resonance, the current amplitude for case R_2 is sharper to that for case R_1.

Quality factor or simply the Q-factor of a resonant LCR circuit is defined as the ratio of voltage drop across the resistance at resonance.

$$Q = \frac{V_L}{V_R} = \frac{\omega L}{R}$$

Thus finally, $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$

The Q factor determines the sharpness at resonance as for higher value of Q factor the tuning of the circuit and its sensitivity to accept resonating frequency signals will be much higher.

At resonance, current in *ac* series LCR circuit is maximum, and depends only on the ohmic resistance R of the circuit. Thus if the ohmic resistance R of series LCR circuit is low, then large current flows in circuit at resonance. So graph C *i.e.*, resistance R_1 has minimum value.

32. (a)(i) $\Delta E = 13.6 \times 3^2 \times \left(\frac{1}{1} - \frac{1}{3^2}\right)$ eV $= 13.6 \times 8$ eV

$$\lambda = \frac{hc}{\Delta E} = \frac{12400}{13.6 \times 8} \text{ Å} = 113.7 \text{ Å}$$

(ii) Number of spectral lines = ${}^nC_2 = {}^3C_2 = 3$

(b) From the given conditions

$E_n - E_2 = (10.2 + 17)$ eV = 27.2 eV ...(i)

and $E_n - E_3 = (4.25 + 5.95)$ eV = 10.2 eV ...(ii)

Equations (i) – (ii) gives

$E_3 - E_2 = 17.0$ eV or $Z^2(13.6)\left(\frac{1}{4} - \frac{1}{9}\right) = 17.0$

$\Rightarrow Z^2(13.6)(5/36) = 17.0 \Rightarrow Z^2 = 9$ or $Z = 3$

From equation (i), $Z^2(13.6)\left(\frac{1}{4} - \frac{1}{n^2}\right) = 27.2$

or $(3)^2(13.6)\left(\frac{1}{4} - \frac{1}{n^2}\right) = 27.2$ or $\left(\frac{1}{4} - \frac{1}{n^2}\right) = 0.222$

or $\frac{1}{n^2} = 0.0278$ or $n^2 = 36 \therefore n = 6$

OR

(i) Bohr's quantization condition : The electron revolves around the nucleus only in those orbits for which the angular momentum is an integral multiple of $h/2\pi$.

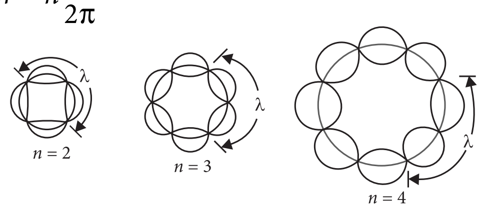
i.e., $L = mvr = n\frac{h}{2\pi}$; $n = 1, 2, 3, ...$

de-Broglie hypothesis may be used to derive Bohr's formula by considering the electron to be a wave spread over the entire orbit, rather than as a particle which at any instant is located at a point in its orbit. The stable orbits in an atom are those which are standing waves. Formation of standing waves require that the circumference of the orbit is equal in length to an integral multiple of the wavelength. Thus, if r is the radius of the orbit

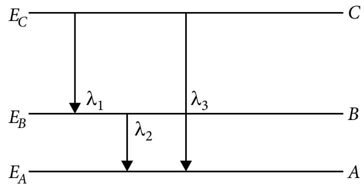
$$2\pi r = n\lambda = \frac{nh}{p} \quad \left(\because \lambda = \frac{h}{p}\right)$$

which gives the angular momentum quantization.

$$L = pr = n\frac{h}{2\pi}$$



(ii)



Clearly, from energy level diagram,

$E_C - E_A = (E_C - E_B) + (E_B - E_A)$

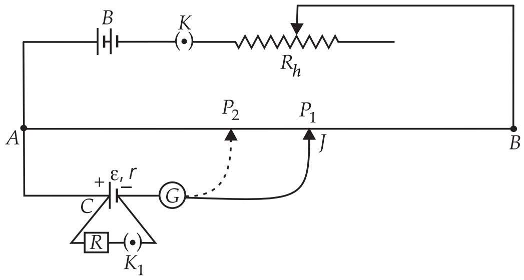
(On the basis of energy of emitted photon).

$$\frac{hc}{\lambda_3} = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2}$$

$$\Rightarrow \frac{1}{\lambda_3} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2} \Rightarrow \lambda_3 = \frac{\lambda_1 \lambda_2}{\lambda_1 + \lambda_2}$$

which is the required relation between the three given wavelengths.

33. The circuit diagram to find the internal resistance of a cell of emf ε using potentiometer is as shown in the figure.



A battery B, a rheostat (R_h) and a key K is connected across the ends A and B of the potentiometer wire such that positive terminal of battery is connected to point A. This completes the primary circuit.

Now the given cell C is connected such that its positive terminal is connected to A and negative terminal to jockey J through a galvanometer. A resistance box (R) and key K_1 are connected across the cell. This completes the secondary circuit.

Method :

(1) Initially key K is closed and a potential difference is applied across the wire AB. Now rheostat (R_h) is so adjusted that on touching the jockey J at ends A and B of potentiometer wire, the deflection in the galvanometer is on both sides. Suppose that in this position the potential gradient on the wire is k.

(2) Now key K_1 is kept open and the position of null deflection is obtained by sliding and pressing the jockey on the wire. Let this position be P_1 and $AP_1 = l_1$. In this situation the cell is in open circuit, therefore the terminal potential difference will be equal to the emf of cell, *i.e.*,

$$\text{emf } \varepsilon = kl_1 \quad \text{...(i)}$$

(3) Now a suitable resistance R is taken in the resistance box and key K_1 is closed. Again, the position of null point is obtained on the wire by using jockey J. Let this position on wire be P_2 and $AP_2 = l_2$.

In this situation the cell is in closed circuit, therefore the terminal potential difference (V) of cell will be equal to the potential difference across external resistance R, *i.e.*,

$$V = kl_2 \quad \text{...(ii)}$$

Dividing (i) by (ii), we get $\dfrac{\varepsilon}{V} = \dfrac{l_1}{l_2}$

∴ Internal resistance of cell,

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

OR

(a) $I_1 = \dfrac{\varepsilon}{r}$ (Without any external resistance)

(b) $I_2 = \dfrac{\varepsilon}{R_1 + r}$ (With resistance R_1 only)

(c) $I_3 = \dfrac{\varepsilon}{R_2 + r}$ (With resistance R_2 only) ($R_2 > R_1$)

(d) $I_4 = \dfrac{\varepsilon}{R_1 + R_2 + r}$ (With R_1 and R_2 in series)

(e) $I_5 = \dfrac{\varepsilon}{\dfrac{R_1R_2}{R_1 + R_2} + r}$ (With R_1 and R_2 in parallel)

From these results, we see

$I_1 > I_5 > I_2 > I_3 > I_4$

From given currents, we note that

$I_1 = 4.2$ A, $I_2 = 1.05$ A, $I_3 = 0.6$ A, $I_4 = 0.42$ A, $I_5 = 1.4$ A

Thus, we have

$$4.2 = \frac{\varepsilon}{r} \quad \text{...(i)}$$

$$1.05 = \frac{\varepsilon}{R_1 + r} \quad \text{...(ii)}$$

$$0.6 = \frac{\varepsilon}{R_2 + r} \quad \text{...(iii)}$$

$$0.42 = \frac{\varepsilon}{R_1 + R_2 + r} \quad \text{...(iv)}$$

$$1.4 = \frac{\varepsilon}{\dfrac{R_1R_2}{R_1 + R_2} + r} \quad \text{...(v)}$$

From equation (i), we get

$$\varepsilon = 4.2r \quad \text{...(vi)}$$

Dividing equation (i) by (ii), we get

$$\frac{R_1 + r}{r} = \frac{4.2}{1.05}$$

or $R_1 + r = 4r$

$$R_1 = 3r \quad \text{...(vii)}$$

Dividing equation (i) by (iii), we get

$$\frac{R_2 + r}{r} = \frac{4.2}{0.6}$$

$$R_2 = 6r \quad \text{...(viii)}$$

Substituting the values of ε, R_1 and R_2 from equations (vi), (vii) and (viii) in equation (iv), we get

$$0.42 = \frac{4.2r}{3r + 6r + r}$$

or $r = 1\ \Omega$

From equation (vi), we get $\varepsilon = 4.2$ V

From equation (vii), we get $R_1 = 3\ \Omega$

From equation (viii), we get $R_2 = 6\ \Omega$

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