DIRECTORATE OF EDUCATION
Govt. of NCT, Delhi

SUPPORT MATERIAL
(2024-2025)

Class : XII

PHYSICS

Under the Guidance of

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Secretary (Education)

Shri R.N. Sharma
Director (Education)

Dr. Rita Sharma
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IAS

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DE.5/228/Exam/Message/SM/2018/555
Dated:- 01/07/2024

MESSAGE

In the profound words of Dr. Sarvepalli Radhakrishnan, **"The true teachers are those who help us think for ourselves."**

Every year, our teams of subject experts shoulder the responsibility of updating the Support Material to synchronize it with the latest changes introduced by CBSE. This continuous effort is aimed at empowering students with innovative approaches and techniques, thereby fostering their problem-solving skills and critical thinking abilities.

I am confident that this year will be no exception, and the Support Material will greatly contribute to our students' academic success.

The development of the support material is a testament to the unwavering dedication of our team of subject experts. It has been designed with the firm belief that its thoughtful and intelligent utilization will undoubtedly elevate the standards of learning and continue to empower our students to excel in their examinations.

I wish to extend my heartfelt congratulations to the entire team for their invaluable contribution in creating this immensely helpful resource for our students.

Wishing all our students a promising and bright future brimming with success.

(ASHOK KUMAR)

R.N. SHARMA, IAS
Director, Education & Sports

सत्यमेव जयते

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DE.5/228/Exam/Message/SM/2018/576
Dated. 04/07/2024

MESSAGE

It brings me great pleasure to present the support material specifically designed for students of classes IX to XII by our dedicated team of subject experts. The Directorate of Education remains resolute in its commitment to empower educators and students alike, extending these invaluable resources at no cost to students attending Government and Government-Aided schools in Delhi.

The support material epitomizes a commendable endeavour towards harmonizing content with the latest CB SE patterns, serving as a facilitative tool for comprehending, acquiring and honing essential skills and competencies stipulated within the curriculum.

Embedded within this initiative is a structured framework conducive to nurturing an analytical approach to learning and problem-solving. It is intended to prompt educators to reflect upon their pedagogical methodologies, forging an interactive conduit between students and academic content.

In the insightful words of Rabindranath Tagore, **"Don't limit a child to your own learning, for he was born in another time."**

Every child is unique, with their own interests, abilities and potential. By allowing children to learn beyond the scope of our own experiences, we support their individual growth and development, helping them to reach their full potential in their own right.

May every student embrace the joy of learning and be empowered with the tools and confidence to navigate and shape the future.

(R. N. SHARMA)

Dr. RITA SHARMA
Additional Director of Education
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D.O. No. DE.5/228/Exam/Message/SM/2018/570
Dated: 02/07/2024

MESSAGE

"Children are not things to be molded, but are people to be unfolded." - Jess Lair

In line with this insightful quote, the Directorate of Education, Delhi, has always made persistent efforts to nurture and unfold the inherent potential within each student. This support material is a testimony to this commitment.

The support material serves as a comprehensive tool to facilitate a deeper understanding of the curriculum. It is crafted to help students not only grasp essential concepts but also apply them effectively in their examinations. We believe that the thoughtful and intelligent utilization of these resources will significantly enhance the learning experience and academic performance of our students.

Our expert faculty members have dedicated themselves to the support material to reflect the latest CBSE guidelines and changes. This continuous effort aims to empower students with innovative approaches, fostering their problem-solving skills and critical thinking abilities.

I extend my heartfelt congratulations to the entire team for their invaluable contribution to creating a highly beneficial and practical support material. Their commitment to excellence ensures that our students are well-prepared to meet the challenges of the CB SE examinations and beyond.

Wishing you all success and fulfilment in your educational journey.

(Dr. Rita Sharma)

DIRECTORATE OF EDUCATION
Govt. of NCT, Delhi

SUPPORT MATERIAL

(2024-2025)

PHYSICS

Class : XII

NOT FOR SALE

PUBLISHED BY : DELHI BUREAU OF TEXTBOOKS

भारत का संविधान

भाग 4क

नागरिकों के मूल कर्तव्य

अनुच्छेद 51 क

मूल कर्तव्य - भारत के प्रत्येक नागरिक का यह कर्तव्य होगा कि वह -

(क) संविधान का पालन करे और उसके आदर्शों, संस्थाओं, राष्ट्रध्वज और राष्ट्रगान का आदर करे;

(ख) स्वतंत्रता के लिए हमारे राष्ट्रीय आंदोलन को प्रेरित करने वाले उच्च आदर्शों को हृदय में संजोए रखे और उनका पालन करे;

(ग) भारत की संप्रभुता, एकता और अखंडता की रक्षा करे और उसे अक्षुण्ण बनाए रखे;

(घ) देश की रक्षा करे और आह्वान किए जाने पर राष्ट्र की सेवा करे;

(ङ) भारत के सभी लोगों में समरसता और समान भ्रातृत्व की भावना का निर्माण करे जो धर्म, भाषा और प्रदेश या वर्ग पर आधारित सभी भेदभावों से परे हो, ऐसी प्रथाओं का त्याग करे जो महिलाओं के सम्मान के विरुद्ध हों;

(च) हमारी सामासिक संस्कृति की गौरवशाली परंपरा का महत्त्व समझे और उसका परिरक्षण करे;

(छ) प्राकृतिक पर्यावरण की, जिसके अंतर्गत वन, झील, नदी और वन्य जीव हैं, रक्षा करे और उसका संवर्धन करे तथा प्राणिमात्र के प्रति दयाभाव रखे;

(ज) वैज्ञानिक दृष्टिकोण, मानववाद और ज्ञानार्जन तथा सुधार की भावना का विकास करे;

(झ) सार्वजनिक संपत्ति को सुरक्षित रखे और हिंसा से दूर रहे;

(ञ) व्यक्तिगत और सामूहिक गतिविधियों के सभी क्षेत्रों में उत्कर्ष की ओर बढ़ने का सतत् प्रयास करे, जिससे राष्ट्र निरंतर बढ़ते हुए प्रयत्न और उपलब्धि की नई ऊँचाइयों को छू सके; और

(ट) यदि माता-पिता या संरक्षक है, छह वर्ष से चौदह वर्ष तक की आयु वाले अपने, यथास्थिति, बालक या प्रतिपाल्य को शिक्षा के अवसर प्रदान करे।

Constitution of India

Part IV A (Article 51 A)

Fundamental Duties

It shall be the duty of every citizen of India —

(a) to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;

(b) to cherish and follow the noble ideals which inspired our national struggle for freedom;

(c) to uphold and protect the sovereignty, unity and integrity of India;

(d) to defend the country and render national service when called upon to do so;

(e) to promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;

(f) to value and preserve the rich heritage of our composite culture;

(g) to protect and improve the natural environment including forests, lakes, rivers, wildlife and to have compassion for living creatures;

(h) to develop the scientific temper, humanism and the spirit of inquiry and reform;

(i) to safeguard public property and to abjure violence;

(j) to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievement;

*(k) who is a parent or guardian, to provide opportunities for education to his child or, as the case may be, ward between the age of six and fourteen years.

Note: The Article 51A containing Fundamental Duties was inserted by the Constitution (42nd Amendment) Act, 1976 (with effect from 3 January 1977).

*(k) was inserted by the Constitution (86th Amendment) Act, 2002 (with effect from 1 April 2010).

भारत का संविधान

उद्देशिका

हम, भारत के लोग, भारत को एक [1][**संपूर्ण प्रभुत्व-संपन्न समाजवादी पंथनिरपेक्ष लोकतंत्रात्मक गणराज्य**] बनाने के लिए, तथा उसके समस्त नागरिकों को :

सामाजिक, आर्थिक और राजनैतिक **न्याय,**

विचार, अभिव्यक्ति, विश्वास, धर्म

और उपासना की **स्वतंत्रता,**

प्रतिष्ठा और अवसर की **समता**

प्राप्त कराने के लिए,

तथा उन **सब में**

व्यक्ति की गरिमा और [2][**राष्ट्र की एकता**

और अखंडता] सुनिश्चित करने वाली **बंधुता**

बढ़ाने के लिए

दृढ़संकल्प होकर **अपनी इस संविधान सभा में** आज तारीख 26 नवंबर, 1949 ई. को **एतद्द्वारा इस संविधान को अंगीकृत, अधिनियमित और आत्मार्पित करते हैं।**

---

1. संविधान (बयालीसवां संशोधन) अधिनियम, 1976 की धारा 2 द्वारा (3.1.1977 से) "प्रभुत्व-संपन्न लोकतंत्रात्मक गणराज्य" के स्थान पर प्रतिस्थापित।
2. संविधान (बयालीसवां संशोधन) अधिनियम, 1976 की धारा 2 द्वारा (3.1.1977 से) "राष्ट्र की एकता" के स्थान पर प्रतिस्थापित।

THE CONSTITUTION OF INDIA

PREAMBLE

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a [1]**[SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC]** and to secure to all its citizens :

JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

EQUALITY of status and of opportunity; and to promote among them all

FRATERNITY assuring the dignity of the individual and the [2][unity and integrity of the Nation];

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949 do **HEREBY ADOPT, ENACT AND GIVE TO OURSELVES THIS CONSTITUTION.**

1. Subs. by the Constitution (Forty-second Amendment) Act, 1976, Sec.2, for "Sovereign Democratic Republic" (w.e.f. 3.1.1977)
2. Subs. by the Constitution (Forty-second Amendment) Act, 1976, Sec.2, for "Unity of the Nation" (w.e.f. 3.1.1977)

MEMBERS OF REVIEW COMMITTEE OF

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5.	Mr. Gautam Prasad Nautiyal	Lecturer Physics	SBS AFPS Sose Jharoda Kalan

CLASS - XII (2024-25)
PHYSICS (THEORY)

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

		No. of Periods	Marks
Unit-I	**Electrostatics**	26	16
	Chapter-1: Electric Charges and Fields		
	Chapter-2: Electrostatic Potential and Capacitance		
Unit-II	**Current Electricity**	18	
	Chapter-3: Current Electricity		
Unit-III	**Magnetic Effects of Current and Magnetism**	25	17
	Chapter-4: Moving Charges and Magnetism		
	Chapter-5: Magnetism and Matter		
Unit-IV	**Electromagnetic Induction and Alternating Currents**	24	
	Chapter-6: Electromagnetic Induction		
	Chapter-7: Alternating Current		
Unit-V	**Electromagnetic Waves**	04	18
	Chapter-8: Electromagnetic Waves		
Unit-VI	**Optics**	30	
	Chapter-9: Ray Optics and Optical Instruments		
	Chapter-**10**: Wave Optics		
Unit-VII	**Dual Nature of Radiation and Matter**	8	12
	Chapter-**11**: Dual Nature of Radiation and Matter		
Unit-VIII	**Atoms and Nuclei**	15	
	Chapter-**12**: Atoms		
	Chapter-**13**: Nuclei		
Unit-IX	**Electronic Devices**	10	7
	Chapter-**14**: Semiconductor Electronics: Materials, Devices and Simple Circuits		
	Total	160	70

Unit I: Electrostatics 26 Periods

Chapter -1: Electric Charges and Fields

Electric Charges; Conservation of charge, Coulomb's law-force between two point charges, forces between multiple charges; superposition principle and continuous charge distribution.

Electric field, electric field due to a point charge, electric field lines, electric dipole, electric field due to a dipole, torque on a dipole in uniform electric field.

Electric flux, statement of Gauss's theorem and its applications to find field due to infinitely long straight wire, uniformly charged infinite plane sheet and uniformly charged thin spherical shell (field inside and outside).

Chapter - 2: Electrostatic Potential and Capacitance

Electric potential, potential difference, electric potential due to a point charge, a dipole and system of charges; equipotential surfaces, electrical potential energy of a system of two-point charges and of electric dipole in an electrostatic field.

Conductors and insulators, free charges and bound charges inside a conductor. Dielectrics and electric polarization, capacitors and capacitance, combination of capacitors in series and in parallel, capacitance of a parallel plate capacitor with and without dielectric medium between the plates, energy stored in a capacitor, (no derivation, formulae only)

Unit II: Current Electricity 18 Periods

Chapter - 3: Current Electricity

Electric current, flow of electric charges in a metallic conductor, drift velocity, mobility and their relation with electric current; Ohm's law, V-l characteristics (linear and non-linear), electrical energy and power, electrical resistivity and conductivity, temperature dependence of resistance, Internal resistance of a cell, potential difference and emf of a cell, combination of cells in series and in parallel, Kirchhoff s rules, Wheatstone bridge,

Unit III: Magnetic Effects of Current and Magnetism 25 Periods

Chapter - 4: Moving Charges and Magnetism

Concept of magnetic field, Oersted's experiment.

Biot - Savart law and its application to current carrying circular loop.

Ampere's law and its applications to infinitely long straight wire. Straight solenoids (only qualitative treatment), force on a moving charge in uniform magnetic and electric fields.

Force on a current-carrying conductor in a uniform magnetic field, force between two parallel current-carrying conductors-definition of ampere, torque experienced by a current loop in uniform magnetic field; moving coil galvanometer-its current sensitivity and conversion to ammeter and voltmeter.

Chapter - 5: Magnetism and Matter

Bar magnet, bar magnet as an equivalent solenoid (qualitative treatment only), magnetic field intensity due to a magnetic dipole (bar magnet) along its axis and perpendicular to its axis (qualitative treatment only), torque on a magnetic dipole (bar magnet) in a uniform magnetic field (qualitative treatment only), magnetic field lines.

Magnetic properties of materials-Para-, dia- and ferro-magnetic substances with examples, Magnetization of materials, effect of temperature on magnetic properties.

Unit IV: Electromagnetic Induction and Alternating Currents 24 Periods

Chapter - 6: Electromagnetic Induction

Electromagnetic induction; Faraday's laws, induced EMF and current; Lenz's Law, Self and mutual induction.

Chapter - 7: Alternating Current

Alternating currents, peak and RMS value of alternating current/voltage: reactance and impedance; LCR series circuit, (phasors only)resonance, power in AC circuits, power factor, watt less current. AC generator and transformer.

Unit V: Electromagnetic waves 04 Periods

Chapter - 8: Electromagnetic Waves

Basic idea of displacement current, Electromagnetic waves, their characteristics, their Transverse nature (qualitative ideas only).

Electromagnetic spectrum (radio waves, microwaves, infrared, visible, ultraviolet, X-rays, gamma rays) including elementary facts about their uses.

Unit VI: Optics 30 Periods

Chapter - 9: Ray Optics and Optical Instruments

Ray Optics: Reflection of light, spherical mirrors, mirror formula, refraction of light, total internal reflection and optical fibers, refraction at spherical surfaces, lenses, thin lens formula, lens maker's formula, magnification, power of a lens, combination of thin lenses in contact, refraction of light through a prism.

Optical instruments: Microscopes and astronomical telescopes (reflecting and refracting) and their magnifying powers.

Chapter -10: Wave Optics

Wave optics: Wave front ana Hagen's principle, reflection and refraction of plane wave at a plane surface using wave fronts. Proof of laws of reflection and refraction using Huygen's principle. Interference, Young's double slit experiment and expression for fringe width, (NO derivation final expression only), coherent sources and sustained interference of light, diffraction due to a single split, with of central maxima (qualitative treatment only)

Unit VII: Dual Nature of Radiation and Matter **08 Periods**

Chapter -11: Dual Nature of Radiation and Matter

Dual nature of radiation, Photoelectric effect, Hertz and Leonard's observations; Einstein's photoelectric equation-particle nature of light. Experimental study of photoelectric effect.

Matter waves-wave nature of particles, de-Broglie relation

Unit VIII: Atoms and Nuclei **15 Periods**

Chapter -12: Atoms

Alpha-particle scattering experiment; Rutherford's model of atom; Bohr model of hydrogen atom, Expression for radius of nth possible orbit, velocity and energy of electron in his orbit, of hydrogen line spectra (qualitative treatment only).

Chapter -13: Nuclei

Composition and size of nucleus, nuclear force

Mass-energy relation, mass defect; binding energy per nucleon and its variation with mass number; nuclear fission, nuclear fusion.

Unit IX: Electronic Devices **12 Periods**

Chapter -14: Semiconductor Electronics: Materials, Devices and Simple Circuits

Energy bands in conductors, semiconductors and insulators (qualitative ideas only) Intrinsic and extrinsic semiconductor-p and n type, p-n junction

Semiconductor diode - 1-V characteristics in forward and reverse bias, application of junction diode-diode as a rectifier.

PRACTICALS (Total Periods 60)

The record to be submitted by the students at the time of their annual examination has to include:

- Record of at least 8 Experiments [with 4 from each section] to be performed by the students.
- Record of at least 6 Experiments [with 3 each from section A and section B] to be performed by the students.
- The Report of the project carried out by the students

Evaluation Scheme

Time Allowed: Three hours **Max. Marks: 30**

Two experiments one from each section	7+7 Marks
Practical record [experiments and activities]	5 Marks
One activity from any section	3 Marks
Investigatory Project	3 Marks
Viva on experiments, activities and project	5 Marks
Total	**30 marks**

SECTION-A

Experiments

1. To determine resistivity of two/three wires by plotting a graph for potential difference versus current
2. To find resistance of given wire/standard resistor using metre bridge
3. To verify the laws of combination (series) of resistances using a metre bridge.

OR

4. To verify the laws of combination (parallel) of resistances using a metre bridge.
5. To determine resistance of a galvanometer by half-deflection method and to find its figure of merit.
6. To convert the given galvanometer (of known resistance and figure of merit) into a voltmeter of desired range and to verify the same.

OR

7. To convert the given galvanometer (of known resistance and figure of merit) into an ammeter of desired range and to verify the same.

Activities (*For the purpose of demonstration only*)

1. To measure the resistance and impedance of an inductor with or without iron core.
2. To measure resistance, voltage (AC/DC), current (AC) and check continuity of a given circuit using multimeter.
3. To assemble a household circuit comprising three bulbs, three (on/off) switches, a fuse and a power source.
4. To assemble the components of a given electrical circuit.
5. To study the variation in potential drop with length of a wire for a steady current.
6. To draw the diagram of a given open circuit comprising at least a battery, resistor/rheostat, key, ammeter and voltmeter. Mark the components that are not connected in proper order and correct the circuit and also the circuit diagram.

SECTION-B

Experiments

1. To find the value of v for different values of u in case of a concave mirror and to find the focal length.
2. To find the focal length of a convex mirror, using a convex lens.
3. To find the focal length of a convex lens by plotting graphs between u and v or between $1/u$ and $1/v$.
4. To find the focal length of a concave lens, using a convex lens.
5. To determine angle of minimum deviation for a given prism by plotting a graph between angle of incidence and angle of deviation.
6. To determine refractive index of a glass slab using a travelling microscope.
7. To find refractive index of a liquid by using convex lens and plane mirror.
8. To find refractive index of a liquid by using concave mirror and plane mirror.
9. To draw the l-V characteristic curve for a p-n junction in forward and reverse

Activities (*For the purpose of demonstration only*)

1. To identify a diode, an LED, a resistor and a capacitor from a mixed collection of such items.
2. Use of multimeter to see the unidirectional flow of current in case of a diode and an LED and check whether a given electronic component (e.g., diode) is in working order.

3. To study effect of intensity of light (by varying distance of the source) on an LDR.
4. To observe refraction and lateral deviation of a beam of light incident obliquely on a glass slab.
5. To observe diffraction of light due to a thin slit.
6. To study the nature and size of the image formed by a (i) convex lens, (ii) concave mirror, on a screen by using a candle and a screen (for different distances of the candle from the lens/mirror).
7. To obtain a lens combination with the specified focal length by using two lenses from the given set of lenses.

Suggested Investigatory Projects

1. To study various factors on which the internal resistance/EMF of a cell depends.
2. To study the variations in current flowing in a circuit containing an LDR because of a variation in
   (a) the power of the incandescent lamp, used to 'illuminate' the LDR (keeping all the lamps at a fixed distance).
   (b) the distance of a incandescent lamp (of fixed power) used to 'illuminate' the LDR.
3. To find the refractive indices of (a) water (b) oil (transparent) using a plane mirror, an convex lens (made from a glass of known refractive index) and an adjustable object needle.
4. To investigate the relation between the ratio of (i) output and input voltage and (ii) number of turns in the secondary coil and primary coil of a self-designed transformer.
5. To investigate the dependence of the angle of deviation on the angle of incidence using a hollow prism filled one by one, with different transparent fluids.
6. To estimate the charge induced on each one of the two identical styrofoam (or pith) balls suspended in a vertical plane by making use of Coulomb's law.
7. To study the factor on which the self-inductance of a coil depends by observing the effect of this coil, when put in series with a resistor/(bulb) in a circuit fed up by an A.C. source of adjustable frequency.
8. To study the earth's magnetic field using a compass needle-bar magnet by plotting magnetic field lines and tangent galvanometer.

QUESTION PAPER DESIGN
Theory (Class:XI/XII)

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

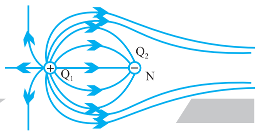
S.No.	Typology of Question	Total Marks	Approximate Percentage
1	**Remembering:** Exhibit memory of previously learned material by recalling facts, terms, basic concepts, and answers. **Understanding:** Demonstrate understanding of facts and ideas by organizing, comparing, translating,	27	38%
2	**Applying:** Solve problems to new situations by applying acquired knowledge, facts, techniques and rules in a different way.	22	32%
3	**Analysing:** Examine and break information into parts by identifying motives or causes. Make inferences and find evidence to support generalizations. **Evaluating:** Present and defend opinion by making judgement about information, validity of ideas , or quality of work based on a set of criteria. **Creating:** Compile information together in a different way by combining elements in a new pattern or proposing alternative solutions	21	30%
	Total Marks	70	100
	Practical	30	
	Gross Total	100	

Note:

The above template is only a sample. Suitable internal variations may be made for generating similar templates keeping the overall weightage to different form of questions and typology of questions same.

For more details kindly refer to sample question Paper of class XII for the year 2023-24 published by CBSE at its website.

INDEX



Unit I and II

Section - 1

KEY POINTS

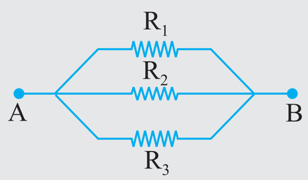
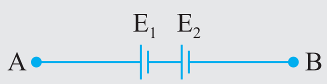
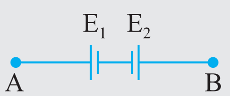
Quantization of charge	$q = \pm ne$	C
Coulomb's force	$\lvert F \rvert = \frac{kq_1q_2}{r^2}$	N
In vector form	$\vec{F}_{12} = \frac{kq_1q_2}{r_{21}^3}\vec{r}_{21} = \frac{kq_1q_2}{r_{21}^2}.\hat{r}_{21}$	
Dielectric constant (or relative permitivity)	$K_D = \in_r = \frac{F_0}{F_m} = \frac{\in_m}{\in_0} = \frac{C_m}{C_0} = \frac{\phi_0}{\phi_m} = \frac{E_0}{E_m}$	Unit less
Hence $F_0 \geq F_m$ as free space has minimum permitivity		
Linear charge density	$\lambda = \frac{q}{L}$	Cm^{-1}
Surface charge density	$\sigma = \frac{q}{A}$	Cm^{-2}
Volume charge density	$\rho = \frac{q}{V}$	Cm^{-3}
Electric field due to a point charge	$\vec{E} = \underset{q_0 \to 0}{\mathrm{Lt}} \frac{\vec{F}}{q_0}$ (theoretical) $\left(\text{In numerical, we use } E = \frac{kq_1}{r^2}\right)$	

The components of electric field,	$E_x = \frac{1}{4\pi\epsilon_0}\frac{q\hat{x}}{r^3}, E_y = \frac{1}{4\pi\epsilon_0}\frac{q\hat{y}}{r^3},$ $E_z = \frac{1}{4\pi\epsilon_0}\frac{q\hat{z}}{r^3}$	NC^{-1}
Torque on a dipole in a uniform electric field	$\vec{\tau} = \vec{p} \times \vec{E}$ (or $\tau = pE \sin\theta$)	Nm
Electric dipole moment	$\vec{p} = q \cdot (2\vec{a})$ or $\lvert \vec{p} \rvert = q(2a)$	Cm
Potential energy of a dipole in a uniform electric field	$U = -\vec{p} \cdot \vec{E}$ (or $U = -pE\cos\theta$)	J
Electric field on axial line of an electric dipole	$E_{axial} = \frac{1}{4\pi\epsilon_0}\frac{2pr}{(r^2 - a^2)^2}$ When $2a << r$, $E_{axial} = \frac{1}{4\pi\epsilon_0}\frac{2p}{r^3}$	NC^{-1}
Electric field on equatorial line of an electric dipole	$E_{equatorial} = \frac{1}{4\pi\epsilon_0}\frac{q2a}{(r^2 + a^2)^{\frac{3}{2}}}$ When $2a << r$, $E_{equatorial}$ $= \frac{1}{4\pi\epsilon_0}\frac{p}{r^3}$	
Electric field as a gradient of potential	$E = -\frac{dV}{dr}$ or $\vec{E} \cdot d\vec{r} = -dV$	
Electric potential differences between ponts A & B	$V_A - V_B = -\frac{W_{AB}}{q_0}$	Volts (or JC^{-1})
Electric potential at a point	$V_A = \frac{1}{4\pi\epsilon_0}\frac{q}{r_A} = \frac{W_{A\infty}}{q}$	

Common potential	$V = \dfrac{C_1V_1 + C_2V_2}{C_1 + C_2}$	
Electric potential due to a system of charges	$V = \dfrac{1}{4\pi \epsilon_0} \sum_{i=1}^{n} \dfrac{q_i}{r_i}$	
Electric potential at any point due to an electric dipole	$V = \dfrac{1}{4\pi \varepsilon_0} \dfrac{p\cos\theta}{(r^2 - a^2\cos^2\theta)}$ When, $\theta = 0°$ or $\theta = 180°$, $V = \dfrac{\pm 1}{4\pi \epsilon_0} \dfrac{p}{(r^2 - a^2)}$ If $r >> a$, $V = \dfrac{1}{4\pi \epsilon_0} \dfrac{p}{r^2}$ When, $\theta = 90°$, $V_{equi} = 0$	
Total electric flux through a closed surface S	$\phi_e = \oint \vec{E}.d\vec{S} = \dfrac{q_{net}}{\epsilon_0}$ q_{net} = Net charge enclosed by a $\Rightarrow$ Gaussian surface	Nm^2C^{-1}
Electric field due to line charge	$E = \dfrac{1}{2\pi\epsilon_0} \dfrac{\lambda}{r}$	NC^{-1} (or V/m)
Electric field due to an infinite plane sheet of charge	$E = \dfrac{\sigma}{2\epsilon_0}$	
Electric field between two infinitely charged plane parallel sheets having change density +s and –s	$E = \dfrac{\sigma}{\epsilon_0}$	
Electric field due to a uniformly charged spherical shell	$E = \dfrac{\sigma}{\epsilon_0} \dfrac{R^2}{r^2}$ When $r = R$, $E_0 = \dfrac{\sigma}{\epsilon_0}$ When $r < R$, $E \times 4\pi r^2 = 0$ $\therefore E = 0$	

Loss of energy (in Parallel compinaton of two capacitors	$\Delta U = \frac{1}{2}\frac{C_1C_2}{(C_1+C_2)}(V_1-V_2)^2$	
Electrical capacitance	$C = \frac{q}{V}$	F(SI Unit)
Capacitance of an isolated sphere	$C_0 = 4\pi\epsilon_0 r$	
Capacitance of a parallel plate	$C = \frac{A\epsilon_0}{d}$	
Capacitors in series	$\frac{1}{C} = \frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}$	
Capacitors in parallel	$C = C_1 + C_2 + C_3$	
Capacitance of a parallel plate capacitor with dielectric slab between plates	$C = \frac{\epsilon_0 A}{d - t\left(1-\frac{1}{K_D}\right)}$	
Capacitance of a parallel plate capacitor with conducting slab between plates	$C = \frac{C_0}{\left(1-\frac{t}{d}\right)}$	
Energy stored in a charged capacitor	$U = \frac{q^2}{2C} = \frac{1}{2}CV^2 = \frac{1}{2}qV$	J
Resultant electric field in a polarised dielectric slab	$\vec{E} = \vec{E}_0 - \vec{E}_p$, where	Cm^{-1}
	$\bar{E}_0$ = Applied electric field and	
	$\bar{E}_p$ = Electric field due to	
polarization		
Polarization density	$P = \epsilon_0 \chi E$	Vm^{-1} or Nc^{-1}
Dielectric constant (in terms of electric susceptibility or atomic polarisability)	$K_D = 1 + \chi$ Where K is dieletric Contant	

CURRENT ELECTRICITY
IMPORTANT FORMULA

1. Drift Velocity	$\vec{v}_d = -\frac{e\vec{E}}{m}\tau$	$\vec{E}$ – electric fluid
2. Relation b/w current and Drift Velocity	$I = neA\upsilon_d$	τ = Relaxation time e = charge on electrons. m = mass of electron n = number density of electrons
3. Ohm's Law	$V = RI$	A = Cross Section Area
4. Resistance	$R = \frac{\rho l}{A}$	V = potential difference across conductor
5. Specific Resistance or Resistivity	$\rho = \frac{RA}{l} = \frac{m}{ne^2\tau}$	l = length of conductor
6. Current density	$j = I/A = neV_d$	
7. Electrical Conductivity	$\sigma = 1/\rho$	
8. Resistances in Series	$R_{eq} = R_1 + R_2 + R_3$	
Parallel Combination	$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$	
9. Temperature Dependance of Resistance	$R_t = R_0(1 + \alpha t)$	R_t = Resistance at t°C a = Cofficent of temprature t = Temperature
10. Internal Resistance of a cell	$r = \left(\frac{E}{V} - 1\right)R$	R_o = Resistance at 0°C
11. Power	$P = VI = I^2R = \frac{V^2}{R}$	
12. Cells in Series	$Eeq = E_1 + E_2$	
Equivalent emf	$Eeq = E_1 - E_2$	$E_1 > E_2$ 
Equivalent Internal Resistance	$r_{eq} = r_1 + r_2$	E_1 & E_2 are emf of two cells
Mobility (μ)	$\frac{v_d}{E}$	CGS unit → $Cm^2s^{-1}v^{-1}$ SI unit → $M^2s^{-1}s^{-}v^{-1}$

		r_1 and r_2 are their internal resistances respectively
Equivalent Current	$I = \dfrac{nE}{R + nr}$	n = no. of cells in series.
13. Cells in parallel	Equivalent e.m.f. $E_{eq} = \dfrac{E_1 r_2 + E_2 r_1}{r_1 + r_2}$ Equivalent resistance $r_{eq} = \dfrac{r_1 r_2}{r_1 + r_2}$	
Equivalent Current	$I = \dfrac{mE}{mR + r}$	m = number of cells in parallel
14. Kirchhoff's Laws	$\Sigma i = 0$ (at a junction) $\Sigma iR = \Sigma E$ or $\Sigma iR = 0$ (in a closed loop)	i = Current R = Resistance E = e.m.f.
15. Wheatstone Bridge (balanced condition)	$\dfrac{P}{Q} = \dfrac{R}{S}$	P, Q, R and S are resistances in Ohm in four arms of Wheatstone Bridge.

UNIT–I & UNIT–II

ELECTROSTATICS AND CURRENT ELECTRICITY

QUESTIONS

(SECTION - A)

VERY SHORT ANSWER QUESTIONS (1 MARK)

1. Two point charges repel each other with a force 'F' when placed in a medium of dielectric constant K. What will be the force between them when placed the same distance apart in air.

   (a) F (b) KF

   (c) $\frac{F}{K}$ (d) $\frac{F}{F}$

2. An electron and a proton are released from rest in a uniform electrostatic field. From the following which one is not correct.

   (a) Both will experience the same force in magnitude

   (b) Proton will have larger acceleration

   (c) Electron will have larger acceleration

   (d) Proton and electron will move in opposite direction

3. A charge q is distributed over a metal sphere of radius R. The electric field and the electric potential at the centre are:

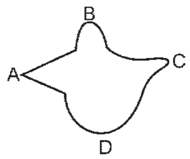
   (a) E = 0, V = 0 (b) $E = \frac{1}{4\pi\varepsilon_0}\frac{q}{R^2}, V = \frac{1}{4\pi\varepsilon_0}\frac{q}{R}$

   (c) $E = 0, V = \frac{1}{4\pi\varepsilon_0}\frac{q}{R}$ (d) $E = \frac{1}{4\pi\varepsilon_0}\frac{q}{R^2}, V = 0$

4. An electric dipele having charages $\pm 2\mu C$ is placed inside a sphere of radius 2m, the net electric flux linked with the sphere is

   (a) 2.26×10^5 Nm²C⁻² (b) 2.26×10^{11} Nm²C⁻²

   (c) 4.56×10^5 nm²C⁻² (d) 0



5. In the metallic conductor shown in thefiruge is continously charged. From which of the following points A, B, C and D does the charge leak first?

(a) A
(b) B
(c) C
(d) D

6. The electric field due to an electric dipole ($\pm q$, $2a$) at a point on equatorial line at distance 'r' from centre of dipole (a < < r) is E. The electric field due to the dipole at distance '2r' on axial line is

(a) 2E
(b) $\frac{E}{2}$
(c) $\frac{E}{4}$
(d) $\frac{E}{8}$

7. In Gause's law $\oint \bar{E}.d\bar{s} = \frac{q}{\varepsilon_0}$, the electric field is

(a) Due to the charges inside the surface only
(b) Due to the changes outside the surface only
(c) Due to all the charges inside and outside the surface
(d) Due to the charges on the surface only

8. An electric dipole is placed in extermal uniform electric field in stable equilibrium position. The potential energy of dipole is

(a) –PE
(b) PE
(c) –2PE
(d) 0

9. The electric flux linked with a sphere of radius 1 m and charge of 17.7×10^{-10}C at its enetre is : ($\varepsilon_0 = 8.85 \times 10^{-12}$ C^2 N^{-1} m^{-2})

(a) 0.02 Nm^2C^{-1}
(b) 2.00Nm^2C^{-1}
(c) 200 Nm^2C^{-1}
(d) 2000 Nm^2C^{-1}

10. Which charge configuration produces a uniform electric field?

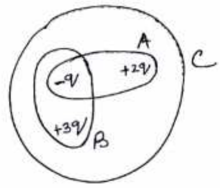
(a) a point charge
(b) infinite unifrom line charge
(c) uniformly charged spherical shell
(d) uniformly charged infinite plane sheet

11. An electric dipole is placed in an electric field of 2×10^5 N/C at an angle of 30° with the direction of field. If dipole length is 1 cm and it experiences a torque of 8Nm, the charge on dipole is

(a) 8 mC (b) 6 mC

(c) 4 mC (d) 2 mC

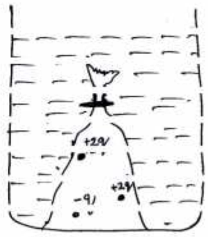
12. From the given figure, find the ratio of electric flux through the Gaussian surfaces A, B & C.



(a) 3 : 4 : 6 (b) 2 : 3 : 5

(c) 1 : 2 : 3 (d) 1 : 2 : 4

13. The total electric flux through the closed surface which is kept inside the water (as shown in the firuge) is :



(a) $\dfrac{5q}{81\varepsilon_0}$ (b) $\dfrac{q}{27\varepsilon_0}$

(c) $\dfrac{27q}{\varepsilon_0}$ (d) $\dfrac{81q}{\varepsilon_0}$

14. Two charged particles havign charges +q and –q are separated by a distance 'r' in air. If they are touched together and then separated to the same distance, the force between them will be

(a) Less than before (b) More than before

(c) Same as before (d) Zero

15. Two points A and B are maintained at a potential of 6V and –4V respectively. The work done in moving are electron from A to B is

(a) 1.6×10^{-18}J (b) -1.6×10^{-18}J

(c) 1.6×10^{-20}J (d) -1.6×10^{-20}J

16. If the voltage applied on a capacitor is incrased from 1V to 2V, choose the correct option

(a) Charge remains the same

(b) Capacitance remains the same

(c) Both charge and capacitance remains same

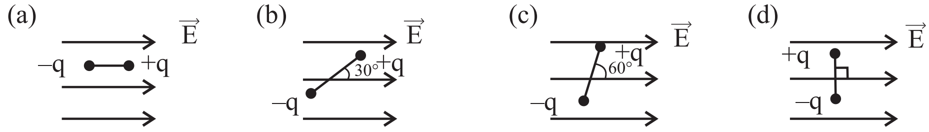
(d) Both charge and capacitance will be doubled

17. Electric dipole moment of $CuSO_4$ molecule is 3.2×10^{-28} C-m. Find the separation between copper and sulphate ions.

(a) 2nm (b) 1 nm

(c) 0.5 nm (d) 0.25 nm

18. An electric dipole is placed in uniform external electric field. From the following diagrams,which one represent half the maximum torque on the dipole.



19. A parallel plate capacitor is charged by a battery and the battery is disconnected. Now the area of the plates of capacitor and the distance between the plates of capacitor are doubled. Which quantity will change?

(a) Capacitance (b) Voltage

(c) energy (d) energy density

20. A positively charged particel is released from rest in a uniform electric field. The electric potential energy of the charge will

(a) remain same (b) increase

(c) decrease (d) become zero

21. Equipotentials at large distance from a collection of charges whose total sum is not zero, are approximately

(a) Spheres (b) Planes

(c) Parabolids (d) ellipsoids

22. Two small identical spheres each carrying a chare 2μC are placed 1 m apart in air. If one of the spheres is taken around the other one in a circular path of radius 1 m, the work done will be equal to

(a) 0.036J (b) 0.36J

(c) 3.6 J (d) Zero

23. A hollow metal sphere of raidus 5 cm is charged so that the potential on its surface is 9V. The potential at the centre of sphere is

(a) Same as at a point 3 cm from the centre of sphere

(b) Same as at a point 5 cm away from the surface of sphere

(c) Some as at a point 3 cm away from the sufrace of sphere

(d) Zero

24. N identical drops each having a charge q and potential V coalesec to form a big drop.

The charge and potential on big drop will be:

(a) Nq, NV respectively (b) Nq, $N^{1/3}$V respectively

(c) Nq, $N^{2/3}$V respectively (d) Nq, V/N respectively

25. A capacitor is charged by using a battery. Battery is disconnected from the capacitor then a dielectric slab is inserted between the plates of capacitor, which results in

(a) decrease in potential difference across the plate

(b) decrease in stored potential energy

(c) bath (a) and (b)

(d) neither (a) nor (b)

26. The work done in bringing a unit positive charge from infinite distance to a point at distance r from a positive charge q is W. The potential at that point is

(a) $\frac{W}{q}$ (b) qW

(c) W (d) $\frac{Wq}{r}$

27. The radii of two metallic spheres of are 10 cm and 15 cm and carrying charge of 75 μC each. If they are shorted then the charge will be transferred

(a) 15 μc from bigger to smaller sphere

(b) 15 μc from smaller to bigger sphere

(e) 25μc from bigger to smaller sphere

(d) 25 μc from smaller to bigger sphere

28. A proton and an α-particle are accelerated from rest through a potential difference of 100 volt. The ratio of their kinetic energy is

(a) 1:1 (b) 1:2

(c) 2:1 (d) 1:4

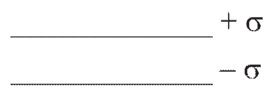
29. There are two conducting spheres of some radii, one is solid and the other is hollow, then

(a) More change can be given to solid sphere

(b) More charge can be given to hollow sphere

(c) Both can be charged equally to maximum

(d) None of the above



30. Two plane sheets of charge densities +σ and – σ are kept in air as shown in the figure. The electric field in the region between the plate is

(a) $\frac{\sigma}{\varepsilon_0}$ (b) $\frac{\sigma}{2\varepsilon_0}$

(c) $\frac{2\sigma}{\varepsilon_0}$ (d) Zero

31. Two copper wires with their lengths in the ratio 1:2 and their resistances are in the ratio 1:2 are connected in series with a battery. The ratio of drift velocities. of free electrons in two wires is

(a) 1:2 (b) 2:1

(c) 1:4 (d) 1:1

32. If 'n' identical cells each of emf ε and internal resistance r are commected in parallel. The equivalent emf and equivalent resectance will be

(a) $\frac{\varepsilon}{n}, \frac{r}{n}$ respectively (b) $n\varepsilon$, nr respectively

(c) $\varepsilon, \frac{r}{n}$ respectively (d) $n\varepsilon, \frac{r}{n}$ respectively

33. Two heating coils, one of thin wire and other of thick wire, made of same material and of same length are connected in turn to a source of emf. Then

(a) Thicker wire will produce more heat

(b) Thiner wire will produce more heat

(c) Both the wires will produce same heat

(d) No wire will produce heat

34. A steady current flour in a metallic conducter of non-emiform cross-section. Which of the quantities remain constant along the length of the conductor?

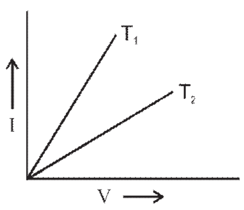
(a) drift speed only

(b) current only

(c) drift speed and current both

(d) drift speed, current and electric field

35. The I-V graph for a given metallic wire at two different temperatures T_1 and T_2 are shown in the figure, then



(a) $T_1 < T_2$ (b) $T_1 > T_2$

(c) $T_1 = T_2$ (d) $T_1 : T_2 = 2 : 1$

36. In the equation A = BC, A is the electric field, B is the current density, then c is

(a) conductivity (b) resistivity

(c) conductance (d) resistance

37. For which of the following relation between drift velocity (V_d) and electric field (E), ohm's law is obeyed

(a) $V_d \times E^{1/2}$ (b) $V_d \times E$

(c) $V_d \times E^2$ (d) $V_d \times \grave{E}^{-1}$

38. The Relaxation time in conductos

(a) increases with increase in temperature

(b) decreases with increase in temperatuure

(c) is independent of temperature

(d) First increase then decreases with increase in temperature

39. The resistance and resistivity of a given wise are R and ρ respectively. If its length and radius both are doubled, then if new resistance and resistivity are R' and ρ' respectively. Then

(a) $R' = 2R, \rho' = 2\rho$ (b) $R' = \frac{R}{2}, \rho' = \frac{\rho}{2}$

(c) $R' = 2R, \rho' = \rho$ (d) $R' = \frac{R}{2}, \rho' = \rho$

40. Kirchhoff's first law, $\sum i = 0$ at a junction and second law $\sum V = 0$ in a closed loop are based on.

(a) conservation of charge, conservation of energy respectively

(b) both on conservation of charge

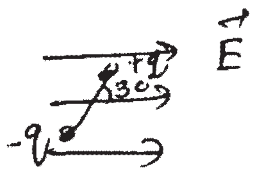
(e) conservation of charge, conservation of energy respectively

(d) Both on conservation of energy

Unit 1 & 8 Unit 2

Answers

1. (b) KF
2. (b) Proton will have larger acceleration
3. (c) E = 0, $v = \frac{1}{4\pi\varepsilon_0}\frac{q}{R}$
4. (d) 0
5. (a) A
6. (c) $\frac{E}{4}$
7. (c) Due to all charges inside and outside the surface only
8. (a) –PE
9. (c) 200 $NM^2\ C^{-1}$
10. (d) Uniformly charged infinite plane seet
11. (a) 8 mc
12. (a) 1 : 2 : 4
13. (b) $\frac{q}{27\varepsilon_0}$
14. (d) Zero
15. (a) 1.6×10^{-18}J
16. (b) capacitance remains the same
17. (b) 1 nm
18. (b)



19. (d) energy density
20. (c) decrease
21. (a) spheres
22. (d) zero

23. (a) Same as at a point 3 cm from the centre of sphere.

24. (c) Nq, $N^{2/3}V$ respectively

25. (c) both (9) & (b)

26. (c) W

27. (b) 15 μc from smaller to bigger sphere

28. (b) 1:2

29. (c) Both can be charged equally to maximum value

30. (a) $\frac{\sigma}{\varepsilon_0}$

31. (d) 1:1

32. (c) $\varepsilon, \frac{r}{n}$ respectively

33. (a) Thicker wire was produce more heat

34. (b) current only

35. (a) $T_1 < T_2$

36. (b) resistivity

37. (b) $V_d \times E$

38. (b) decreases with increase in temperative

39. (d) $R' = \frac{R}{2}, \rho' = \rho$

40. (c) conservation of chaye, comulation of energy respectively

Assertion and Reason based questions on electrostatics

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

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

b) Both A & 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

41. Assertion : Electrons move away from a region of lower potential to a region of higher potential.

    Reason : Because electron is a negatively charged partiels.

42. Assertion : Work done in moving any charge between two points on an equipotential surface is zero.

    Reason : Because an equipotential surface is that surface which has always zero potential at all points on it.

43. Assertion : A point charge q is placed at a distance a/2 directly above the centre of square of side a. The magnitude of electric flux associated with the square is independent of side length of the square.

    Reason : Gauss's law is independent of size of Gaussian surface.

44. Assertion : Work done in moving a change between any two points in an electrostatic field is independent of the path followed by the charge between these points.

    Reason : Electrostatic force is not conservative force.

45. Assertion : Net electric field inside a conductor is zero.

Reason : Total positive charge equals total negative charge in a charged conductor.

Answer Key :

(1) a)

(2) c)

(3) a)

(4) c)

(5) c)

Assertion and Reason Based Question on Current Electricity

For these question, two statements are given-one labelled Assertion A and the other labelled Reason (R). Select the correct answer to these question 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

46. Assertion: An electric bulb starts glowing instantly as it is switched on.
    Reason: Drift velocity of electrons in a metallic wire is very large.

47. Assertion : When cells are connected in parallel to the external load, the effective e.m.f. increases.

    Reason : All the cells will be sending the current to the external load in the same direction.

48. Assertion : Electrons move from a region of higher potential to a region of lower potential.

    Reason : An electron has less potential energy at a point where potential is higher and vice-versa.

49. Assertion : In series combination of electric bulbs the bulb of lower power emits more light than that of higher power bulb.

    Reason : The lower power bulb in series gets more current than higher power bulb.

50. Assertion : The drift velocity of electrons in a metallic wire decreases, when temperature of the wire increases.

Reason : On increasing temperature, conductivity of metallic wire decreases.

Answer Key :

(46)	c)
(47)	d)
(48)	c)
(49)	c)
(50)	b)

CASE STUDY ELECTROSTATICS

Static Electricity : Static electricity is the build up of an electrical charge on the surface of an object. We see static electricity everyday. When our dry hairs are dressed with a plastic comb, hairs get charged. Lightning is a powerful form of static electricity. Atoms are made up of tiny particles called neutrons, protons and electrons. The neutrons and protons together form the nucleus. The electrons revolve around the outside of the nucleus. A static charge is formed when two surface are rubbed against each other and the electrons move from one object to another.

Each question carries 1 mark.

1. Which atomic particle move from one surface to another in order to form static charge?

   a) Electrons b) Protons

   c) Neutrons d) All of the above

2. What is static electricity?

   a) Electricity that flows in one direction

   b) Electricity that constantly changes direction

   c) An electric charge on the surface of an object

   d) Electricity that is sent over the air

3. When a charged rod is brought near a neutral paper piece, then charged rod

a) Attracts the paper piece

b) Repels the paper piece

c) Neither attract nor repel the paper piece

d) None of the above

4. Which of the following is/are practical application for static electricity?

a) Air filters b) Photocopier

c) Laser printers d) All of the above

5. Which of the following is an example of static electricity?

a) Electricity for a light bulb

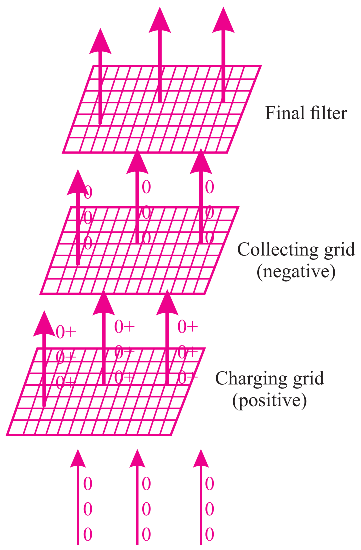
b) An electric socket in your home

c) Your pants sticking to yours legs

d) None of the above

Air Cleaner

II In cleaners, the air is passed through a grid which charges the particles in air (like as smoke, dust, pollen etc) positively (usually) and them the air is passed through oppositely charged grid that attracts and retain the charged particles. So clean air is obtained by air cleaner.



Each question carriers 1 Mark.

1. Negative charge on a body is due to

a) Excess of electrons on the body

b) deficiency of electrons on the body

c) Passing electric current through the body

d) None of the above

2. When a charged body is placed near neutral piece of paper, it attracts the paper due to

a) Electrical induction b) Self induction

c) Mutual induction d) None of the above

3. When two bodies are rubbed against each other them they get charge due to

a) Transfer of electrons b) Transfer of protons

c) Transfer of neutrons d) None of the above

4. Air cleaner works on

a) Magnetism b) current

c) Electrostatics d) Mutual induction

5. Which of the following is a practical application of static electricity?

a) Cyclotron b) Photocopier

c) Transformer d) AC Generator

Answer Key : Static Electricity

(1) a)

(2) c)

(3) a)

(4) d)

(5) c)

Answer Key : Air Cleaner

(1) a)

(2) a)

(3) a)

(4) c)

(5) b)

III. **<u>Temperature Dependence of Resistivity</u>**

The resistivity of a material is found to be dependent on the temperature. Different materials do not exhibit the same dependence on temperature. Over a limited range of temperatures, that is not too large, the resistivity of a metallic conductor is approximately given by $\rho_T = \rho_0[1+\alpha(T-T_0)]$

Where ρ_T is the resistivity at a temperature T and ρ_0 is the same at a reference temperature T_0. α is called the temperature co-efficient of resistivity. For the metals α is positive, meaning that resistivity increase with increasing temperature. for non metals α is negative and for some metal alloys it is very small.

1. The resistance of insulators---------

   a) increases with increase in temperature

   b) decreases with increase in temperature

   c) is independent of temperature

   d) None of the above

2. What is the unit of temperature coefficient of resistivity ?

   a) $\Omega m^{o}c^{-1}$

   b) $\Omega m^{o}c$

   c) ^{0}C

   d) $^{0}C^{-1}$

3. Standard resistance coils are made of

   a)metals

   b)insulators

   c)semiconductors

   d) alloys of metal

4. The resistance values of constantan and manganin would change _________ with temperature.

   a)very little

   b)large

   c)very large

   d) does not change

5. The resistivity of metals---------

a) decreases with decrease in temperature

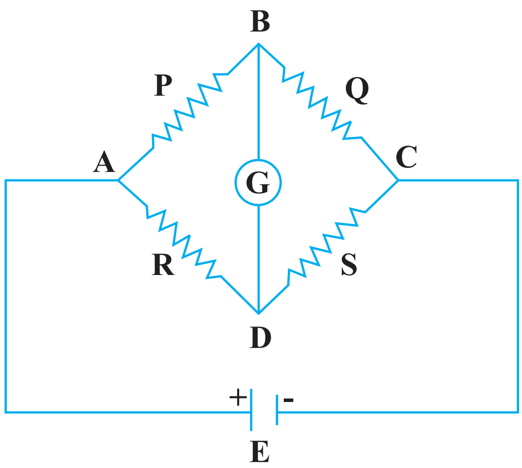
b) decreases with increase in temperature

c) is independent of temperature

d) None of the above

Answer Key : 1. (a), 2. (d), 3. (d), 4. (a), 5. (a)

IV The Wheatstone bridge works on the principle of null deflection, i.e. if the ratio of their resistances are equal and no current flows through the circuit given in figure. The working of metre bridge is based on Wheatstone bridge principle. The meter bridge is used to find the resistance of unknown conductor or to compare two unknown resistances.



1 When galvanometer shows null deflection

a) $V_B > V_D$

b) $V_B < V_D$

c) $V_B = V_D$

d) Can't be determined

2. Wheatstone bridge is a/an:

a) A.C. bridge

b) D.C bridge

c) High bridge

d) None of these

3. Whetstone bridge is used to measure resistance of various type of wires for :

a) Determining their effective resistance

b) Computing the power dissipation

c) Quality control of wire

d) None of these

4. By using variations on a Wheatstone bridge we can :

a) Measure quantities such as voltage, current and power

b) Measure high resistance values

c) Measure complex power

d) Measure quantities such as capacitance, inductance and impedance

5. The given Wheatstone bridge is said to be balanced when :

a) $\frac{P}{R} = \frac{Q}{S}$

b) P+R=Q+S

c) P-Q=R-S

d) P.R=Q.S

Answer Key

1(c) 2(b) 3(a) 4(b) 5(a)

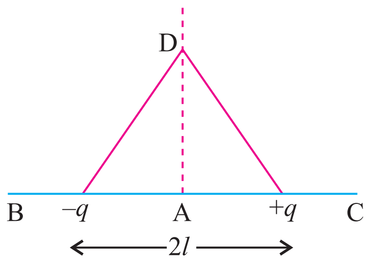
SHORT ANSWER QUESTIONS (2 MARKS)

1. An oil drop of mass m carrying charge – Q is to be held stationary in the gravitational field of the earth. What is the magnitude and direction of the electrostatic field required for this purpose ? **Ans.** E = mg/Q, downward
2. Draw E and V versus r on the same graph for a point charge.
3. Find position around dipole at which electric potential due to dipole is zero but has non zero electric field intensity.

   Ans. Equatorial position, V = 0, $\vec{E} = \frac{-1}{4\pi\epsilon_0}\frac{\vec{p}}{r^3}$ (a << r)

4. Derive an expression for the work done in rotating an electric dipole from its equilibrium position to an angle θ with the uniform electrostatic field.
5. A electrostatic field line can not be discontinuous.Why ?
6. A thin long conductor has linear charge density of 20 μC/m. Calculate the electric field intensity at a point 5 cm from it. Draw a graph to show variation of electric field intensity with distance from the conductor.

   Ans. 72×10^5 N/C
7. What is the ratio of electric field intensity at a point on the equatorial line to the field at a point on axial line when the points are at the same distance from the centre of the dipole ? **Ans.** 1 : 2
8. Show that the electric field intensity at a point can be given as negative of potential gradient.
9. A charged metallic sphere A having charge q_A is brought in contact with an uncharged metallic sphere of same radius and then separated by a distance d. What is the electrostatic force between them. **Ans.** $\frac{1}{16\pi\epsilon_0}\frac{q_A^2}{d^2}$
10. An electron and a proton travel through equal distances in the same uniform electric field E. Compare their time of travel. (Neglect gravity)
11. Two point charges – q and + q are placed $2l$ metre apart, as shown in Fig. Give the direction of electric field at points A, B, C and D, A is mid point between charges – q and + q.

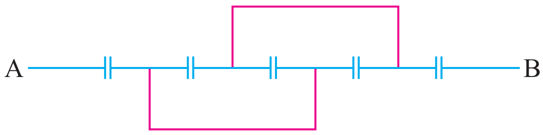


12. The electric potential V at any point in space is given $V = 20x^3$ volt, where x is in meter. Calculate the electric intensity at point P (1, 0, 2).

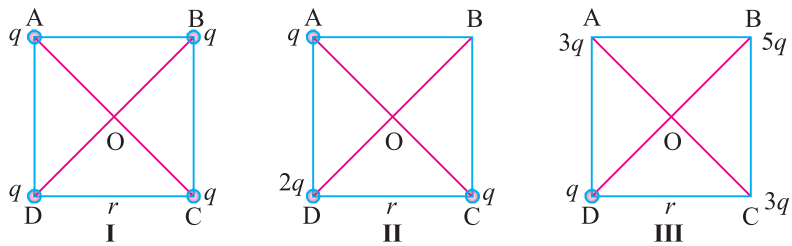
Ans. – 60 NC^{-1}

13. Justify why two equipotential surfaces cannot intersect.

14. Find equivalent capacitance between A and B in the combination given below : each capacitor is of 2 μF. **Ans.** 6/7 μF



15. What is the electric field at O in Figures (i), (ii) and (iii), ABCD is a square of side r.



Ans. (i) Zero, (ii) $\dfrac{4q}{4\pi\varepsilon_0 r^2}$ along OB (iii) $\dfrac{8q}{4\pi\varepsilon_0 r^2}$ along OD

16. What should be the charge on a sphere of radius 4 cm, so that when it is brought in contact with another sphere of radius 2 cm carrying charge of 10 μC, there is no transfer of charge from one sphere to other ?

Ans. $Va = Vb$, $Q = 20\mu C$.

17. For an isolated parallel plate capacitor of capacitance C and potential difference V, what will be change in (i) charge on the plates (ii) potential difference across the plates (iii) electric field between the plates (iv) energy stored in the capacitor, when the distance between the plates is increased ?

Ans. (i) No change (ii) increases (iii) No change (iv) increases.

18. Does the maximum charge given to a metallic sphere of radius R depend on whether it is hollow or solid ? Give reason for your answer.

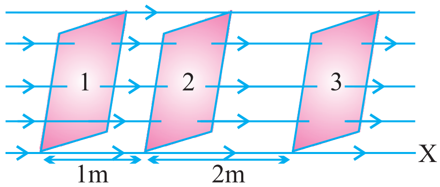
Ans. No, charge resides on the surface of conductor.

19. Two charges Q_1 and Q_2 are separated by distance r. Under what conditions will the electric field be zero on the line joining them (i) between the charges (ii) outside the charge?

Ans. (i) Charge are alike (ii) Unlike charges of unequal magnitude.

20. Obtain an expression for the electric field due to electric dipole at any point on the equatorial line.

21. The electric field component in the figure are $\vec{E}_x = 2x\hat{i}$, $\vec{E}_y = E_z = 0$. Calculate the electric flux through, (1, 2, 3) the square surfaces of side 5 m.



22. Calculate the work required to separate two charges 5μc and – 2μc placed at (– 3 cm, 0, 0) and (+ 3 cm, 0, 0) infinitely away from each other.

Ans. 1.5 J

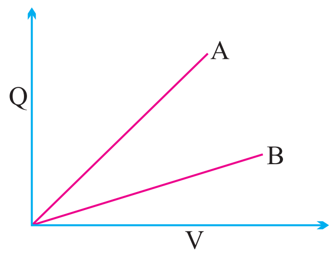
23. What is electric field between the plates with the separation of 2 cm and (i) with air (ii) dielectric medium of dielectric constant K. Electric potential of each plate is marked in the following figure.

______________ 150 V

(i) _______________ – 50 V **Ans.** $E_0 = 10^4 \text{ NC}^{-1}$, $E = \dfrac{10^4}{k} \text{NC}^{-1}$

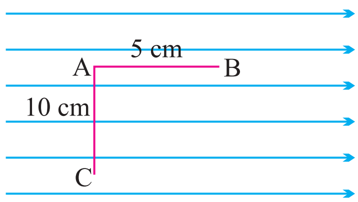
24. A RAM (Random access Memory) chip a storage device like parallel plate capacitor has a capacity of 55pF. If the capacitor is charged to 5.3V, how many excess electrons are on its negative plate ? **Ans.** 1.8×10^9

25. The figure shows the Q (charge) versus V (potential) graph for a combination of two capacitors. identify the graph representing the parallel combination.



Ans. A represents parallel combination

26. Calculate the work done in taking a charge of 1 μC in a uniform electric field of 10 N/C from B to C given AB = 5 cm along the field and AC = 10 cm perpendicular to electric field.



Ans. $W_{AB} = W_{BC} = 50 \times 10^{-8}$ J. $W_{AC} = 0$J

27. Two charges $-q$ and $+q$ are located at points A (0, 0, $-a$) and B (0, 0, $+a$) respectively. How much work is done in moving a test charge from point P (7, 0, 0) to Q (– 3, 0, 0) ? (zero)

28. The potential at a point A is – 500 V and that at another point B is + 500 V. What is the work done by external agent to take 2 units (S.I.) of negative charge from B to A. $W_{BA} = 2000$ J

29. How does the (i) Potential energy of mutual interaction (ii) net electrostatic P.E. of two charges change when they are placed in an external electric field.

30. With the help of an example, show that Farad is a very large unit of capacitance.

31. What is meant by dielectric polarisation ? Why does the electric field inside a dielectric decreases when it is placed in an external field ?

32. In charging a capacitor of capacitance C by a source of emf V, energy supplied by the sources QV and the energy stored in the capacitor is ½QV. Justify the difference.

33. An electric dipole of dipole moment p, is held perpendicular to an electric field. If the dipole is released does it have (a) only rotational motion

(b) only translatory motion (c) both translatory and rotatory motion explain?

34. The net charge of a system is zero. Will the electric field intensity due to this system also be zero.

35. A point charge Q is kept at the intersection of (i) face diagonals (ii) diagonals of a cube of side a. What is the electric flux linked with the cube in (i) & (ii) ?

36. There are two large parallel metallic plates S_1 and S_2 carrying surface charge densities σ_1 and σ_2 respectively ($\sigma_1 > \sigma_2$) placed at a distance d apart in vacuum. Find the work done by the electric field in moving a point charge q a distance a ($a < d$) from S_1 and S_2 along a line making an angle $\pi/4$ with the normal to the plates.

37. Define mobility of electron in a conductor. How does electron mobility change when (i) temperature of conductor is decreased (ii) Applied potential difference is doubled at constant temperature ?

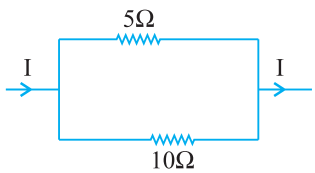
38. On what factors does emf of a cell depend?

39. What are superconductors ? Give one of their applications.

40. Two copper wires with their lengths in the ratio 1 : 2 and resistances in the ratio 1 : 2 are connected (i) in series (ii) in parallel with a battery. What will be the ratio of drift velocities of free electrons in two wires in (i) and (ii) ? **Ans.** (1 : 1, 2 : 1)

41. The current through a wire depends on time as $i = i_0 + at$ where $i_0 = 4\text{A}$ and $a = 2\text{As}^{-1}$. Find the charge crossing a section of wire in 10 seconds.

42. In the arrangement of resistors shown, what fraction of current I will pass through 5Ω resistor ? $\left(\frac{2I}{3}\right)$

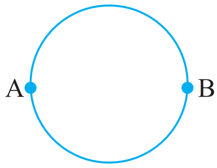


43. A 100W and a 200 W domestic bulbs joined in series are connected to the mains. Which bulb will glow more brightly ? Justify. (100W)

44. A 100W and a 200 W domestic bulbs joined in parallel are connected to the mains. Which bulb will glow more brightly ? Justify. (200W)

45. A battery has an emf of 12V and an internal resistance of 2Ω. Calculate the potential difference between the terminal of cell if (a) current is drawn from the battery (b) battery is charged by an external source.

46. A uniform wire of resistance R ohm is bent into a circular loop as shown in the figure. Compute effective resistance between diametrically opposite points A and B. **[Ans.** R/4]



47. A household circuit has a fuse of 5A rating calculate the maximum number of bulbs of rating 100W-220V each can be connected in this household circuit
Ans. Current drawn by each bulb $= \frac{p}{v} = \frac{100}{220} = \frac{5}{11}$ A No. of bulbs that can be safely used with 5A fuse $= \frac{5}{\frac{5}{11}} =$ 11 bulbs

48. Two heating coils, one of thin wire and other of thick wire, made of same material and of same length are connected in turn to a source of emf. Which one of the coils will produce more heat ?

Ans $P = \frac{V^2}{R}$, for same V, thicker wire has low resistance so it will more produce more heat.

49. A wheatstone bridge is in balance condition. Now if galvanometer and cell are interchanged, the galvanometer shows no deflection. Give reason.
[Ans. Galvanometer will show no deflection. Proportionality of the arms are retained as the galvanometer and cell are interchanged.]

50. Give any two limitations of Ohm's law.

51. Which one of the two, an ammeter or a milliammeter has a higher resistance and why ? Ans. milliammeter

52. Name two factors on which the resistivity of a given material depends ?

53. If the electron drift speed is so small ($\sim 10^{-3}$ m/s) and the electron's charge is very small, how can we still obtain a large amount of current in a conductor.

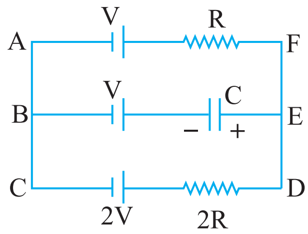
54. A battery of emf 2.0 volts and internal resistance 0.1Ω is being charged with a current of 5.0 A. What is the potential difference between the terminals of the battery ?

55. Five identical cells, each of emf E and internal resistance *r*, are connected in series to form (a) an open (b) closed circuit. If an ideal voltmeter is connected across three cells, what will be its reading ?

[Ans. (a) 3E; (b) zero]

56. An electron in a hydrogen atom is considered to be revolving around a proton with a velocity $\frac{e^2}{n}$ in a circular orbit of radius $\frac{n^2}{me^2}$. If I is the equivalent current, express it in terms of *m, e, n*.

57. In the given circuit, with steady current, calculate the potential drop across the capacitor in terms of V.



58. A cell of e.m.f. 'E' and internal resistance '*r*' is connected across a variable resistor 'R'. Plot a graph showing the variation of terminal potential 'V' with resistance 'R'. Predict from the graph the condition under which 'V' becomes equal to 'E'.

59. Winding of rheostat wire are quite close to each other why do not they get short circuted ?

Ans. The wire has a coating of insulating oxide over it which insulate the winding from each other.

60. The current I flows through a wire of radius r and the free electrons drift with velocity v_d. When a current 2I flows through the wire of same material but having double the radius, what will be the drift velocity of electrons in this wire

Ans.
$$v_d = \frac{I}{nAe} = \frac{I}{n.\pi r^2 e}$$

$$v_{d'} = \frac{2I}{n.\pi(2r)^2 e} = \frac{1}{2} v_d$$

SHORT ANSWER QUESTIONS (3 MARKS)

1. Define electrostatic potential and its unit. Obtain expression for electrostatic potential at a point P in the field due to a point charge.
2. Calculate the electrostatic potential energy for a system of three point charges placed at the corners of an equilateral triangle of side '*a*'.
3. What is polarization of charge ? With the help of a diagram show why the electric field between the plates of capacitor reduces on introducing a dielectric slab. Define dielectric constant on the basis of these fields.
4. Using Gauss's theorem in electrostatics, deduce an expression for electric field intensity due to a charged spherical shell at a point (i) inside (ii) on

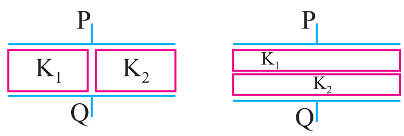
its surface (iii) outside it. Graphically show the variation of electric field intensity with distance from the centre of shell.

5. Three capacitors are connected first in series and then in parallel. Find the equivalent capacitance for each type of combination.

6. A charge Q is distributed over two concentric hollow sphere of radii r and R (R > r), such that their surface density of charges are equal. Find Potential at the common centre.

7. Derive an expression for the energy density of a parallel plate capacitor.

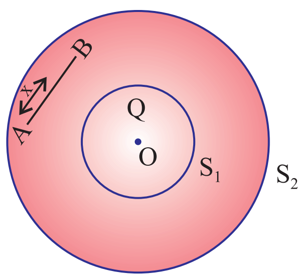
8. You are given an air filled parallel plate capacitor. Two slabs of dielectric constants K_1 and K_2 having been filled in between the two plates of the capacitor as shown in Fig. What will be the capacitance of the capacitor of initial area was A distance between plates d ?



Ans. $C_1 = (K_1 + K_2)C_0$

$$C_2 = \frac{K_1K_2C_0}{(K_1 + K_2)}$$

9. In the figure shown, calculate the total flux of the electrostatic field through the sphere S_1 and S_2. The wire AB shown of length l has a liner charge density λ given $\lambda = kx$ where x is the distance measured along the wire from end A.



Ans. Total charge on wire AB = $Q = \int_o^l \lambda dx = \int_o^l k\ x\ dx = \frac{1}{2}kl^2$

By Gauss's theorem.

Total flux through $S_1 = \dfrac{Q}{\epsilon_0}$

Total flux through $S_2 = \dfrac{Q + \frac{1}{2} k l^2}{\epsilon_0}$

10. Explain why charge given to a hollow conductor is transferred immediately to outer surface of the conductor.

11. Derive an expression for total work done in rotating an electric dipole through an angle θ in an uniform electric field. Hence calculate the potential energy of the dipole.

12. Define electric flux. Write its SI unit. An electric flux of f units passes normally through a spherical Gaussian surface of radius *r*, due to point charge placed at the centre.

(1) What is the charge enclosed by Gaussian surface ?

(2) If radius of Gaussian surface is doubled, what will be the flux through it ?

13. A conducting slab of thickness '*t*' is introduced between the plates of a parallel plate capacitor, separated by a distance *d* ($t < d$). Derive an expression for the capacitance of the capacitor. What will be its capacitance when $t = d$?

14. If a dielectric slab is introduced between the plates of a parallel plate capacitor after the battery is disconnected, then how do the following quantities change.

(i) Charge

(ii) Potential

(iii) Capacitance

(iv) Energy.

15. What is an equipotential surface ? Write three properties Sketch equipotential surfaces of

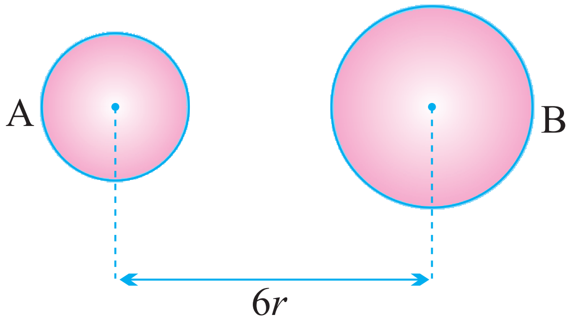
(i) Isolated point charge

(ii) Uniform electric field

(iii) Dipole

16. If charge Q is given to a parallel plate capacitor and E is the electric field between the plates of the capacitor the force on each plate is 1/2 QE and if charge Q is placed between the plates experiences a force equal to QE. Give reason to explain the above.

17. Two metal spheres A and B of radius r and $2r$ whose centres are separated by a distance of $6r$ are given charge Q, are at potential V_1 and V_2. Find the ratio of V_1/V_2. These spheres are connected to each other with the help of a connecting wire keeping the separation unchanged, what is the amount of charge that will flow through the wire ?



18. Define specific resistance. Write its SI unit. Derive an expression for resistivity of a wire in terms of its material's parameters, number density of free electrons and relaxation time.

19. A potential difference V is applied across a conductor of length L and diameter D. How are the electric field E and the resistance R of the conductor affected when (i) V is halved (ii) L is halved (iii) D is doubled. Justify your answer.

20. Define drift velocity. A conductor of length L is connected to a dc source of emf E. If the length of conductor is tripled by stretching it, keeping E constant, explain how do the following factors would vary in the conductor ?

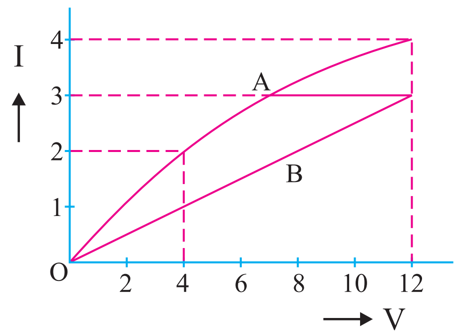
(i) Drift speed of electrons (ii) Resistance and (iii) Resistivity

21. Define conductivity of a substance. Give its SI units. How does it vary with temperature for (i) Copper (ii) Silicon ?

22. Two cells of emf E_1 and E_2 having internal resistance r_1 and r_2 are connected in parallel. Calculate E_{eq} and r_{er} for the combination.

23. The graph A and B shows how the current varies with applied potential difference across a filament lamp and nichrome wire respectively. Using the graph, find the ratio of the values of the resistance of filament lamp to the nichrome wire

(i) when potential difference across them is 12 V.



(ii) when potential difference across them is 4V. Give reason for the change in ratio of resistance in (i) and (ii).

24. Electron drift speed is estimated to be only a few mm/s for currents in the range of few amperes ? How then is current established almost the instant a circuit is closed.

25. Give three differences between e.m.f. and terminal potential difference of a cell.

26. Define the terms resistivity and conductivity and state their S. I. units. Draw a graph showing the variation of resistivity with temperature for a typical semiconductor.

27. The current flowing through a conductor is 2mA at 50V and 3mA at 60V. Is it an ohmic or non-ohmic conductor ? Give reason.

28. Nichrome and copper wires of same length and area of cross section are connected in series, current is passed through them why does the nichrome wire get heated first ?

29. Under what conditions is the heat produced in an electric circuit :

(i) directly proportional

(ii) inversely proportional to the resistance of the circuit.

LONG ANSWER QUESTIONS (5 MARKS)

1. Two charged capacitors are connected by a conducting wire. Calculate common potential of capacitors (ii) ratio of their charges at common potential. Show that energy is lost in this process.
2. Derive an expression for the strength of electric field intensity at a point on the axis of a uniformly charged circular coil of radius R carrying charge Q.
3. Derive an expression for potential at any point distant r from the centre O of dipole making an angle θ with the dipole.
4. Suppose that three points are set at equal distance r = 90 cm from the centre of a dipole, point A and B are on either side of the dipole on the axis (A closer to +ve charge and B closer to negative charge) point C which is on the perpendicular bisector through the line joining the charges. What would be the electric potential due to the dipole of dipole moment 3.6 × 10^{19} Cm at points A, B and C ?
5. Derive an expression for capacitance of parallel plate capacitor with dielectric slab of thickness $t(t < d)$ between the plates separated by distance d. How would the following (i) energy (ii) charge, (iii) potential be affected (a) if dielectric slab is introduced with battery disconnected, (b) dielectric slab is introduced after the battery is connected.
6. Derive an expression for torque experienced by dipole placed in uniform electric field. Hence define electric dipole moment.
7. State Gauss's theorem. Derive an expression for the electric field due to a charged plane sheet. Find the potential difference between the plates of a parallel plate capacitor having surface density of charge 5×10^{-8} Cm^{-2} with the separation between plates being 4 mm.
8. Define current density. Give its SI unit. Whether it is vector or scalar ? How does it vary when (i) potential difference across wire increases (ii) length of wire increases (iii) temperature of wire increases (iv) Area of cross-section of wire increases justify your answer.

9. Using Gauss's theorem obtain an expression for electric field intensity due to a plane sheet of charge. Hence obtain expression for electric field intensity in a parallel plate capacitor.

10. Write any four important results regarding electro statics of conductors.

11. State Kirchhoffs's rules for electrical networks. Use them to explain the principle of Wheatstone bridge for determining an unknown resistance. How is it realized in actual practice in the laboratory ? Write the formula used.

12. For three cells of emf E_1, E_2 and E_3 with internal resistance r_1, r_2, r_3 respectively connected in parallel, obtain an expression for net internal resistance and effective current. What would be the maximum current possible if the emf of each cell is E and internal resistance is r each ?

13. Derive an expression for drift velocity of the electron in conductor. Hence deduce ohm's law.

14. How does the internal resistance of a cell change in the following cases-

(i)When concentration of electrolyte is increased

(ii)When area of the anode is increased

(iii)When temperature of electrolyte is decreased

Ans. (i) increases (ii) decrease (iii) increases

15. Explain how does the conductivity of a :

(i) Metallic conductor

(ii) Semi conductor and

(iii) Insulator varies with the rise of temperature.

16. Derive expression for equivalent e.m.f. and equivalent resistance of a :

(a) Series combination

(b) Parallel combination

of three cells with e.m.f. E_1, E_2, E_3 & internal resistances r_1, r_2, r_3 respectively.

17. Deduce the condition for balance in a Wheatstone bridge, using the Kirchhoff's law

NUMERICALS

1. What should be the position of charge $q = 5\mu C$ for it to be in equilibrium on the line joining two charges $q_1 = -4\ \mu C$ and $q_2 = 16\ \mu C$ separated by 9 cm. Will the position change for any other value of charge q ? (9 cm from – 4 μC)

2. Two point charges 4e and e each, at a separation r in air, exert force of magnitude F. They are immersed in a medium of dielectric constant 16. What should be the separation between the charges so that the force between them remains unchanged. (1/4 the original separation)

3. Two capacitors of capacitance 10 μF and 20 μF are connected in series with a 6V battery. If E is the energy stored in 20 μF capacitor what will be the total energy supplied by the battery in terms of E. (6E)

4. Two point charges 6 μC and 2 μC are separated by 3 cm in free space. Calculate the work done in separating them to infinity. (3. 6 joule)

5. ABC is an equilateral triangle of side 10 cm. D is the mid point of BC charge 100 μC,– 100μC and 75 μC are placed at B, C and D respectively. What is the force experienced by a 1 μC positive charge placed at A ?

$$(90\sqrt{2} \times 10^3 \text{ N})$$

6. A point charge of 2 μC is kept fixed at the origin. Another point charge of 4 μC is brought from a far point to a distance of 50 cm from origin. (a) Calculate the electrostatic potential energy of the two charge system. Another charge of 11 μC is brought to a point 100 cm from each of the two charges. What is the work done ? (a) 144×10^{-3} J

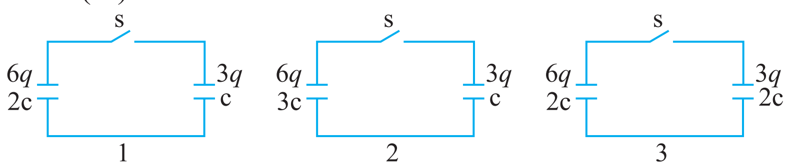
7. A 5 MeV α particle is projected towards a stationary nucleus of atomic number 40. Calculate distance of closest approach. (1.1×10^{-4} m)

8. To what potential must a insulated sphere of radius 10 cm be charged so that the surface density of charge is equal to 1 $\mu C/m^2$. ($1.13 \times 10^4 V$)

9. A slab of material of dielectric constant K has the same area as the plates of parallel plate capacitor but its thickness is $\frac{3d}{4}$, where d is separation between plates, How does the capacitance change when the slab is inserted between the plates ?

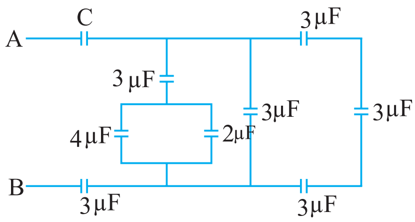
10. A point charge developes an electric field of 40 N/C and a potential difference of 10 J/C at a point. Calculate the magnitude of the charge and the distance from the point charge. (2.9×10^{-10} C, 25 cm)

11. Figure shows three circuits, each consisting of a switch and two capacitors initially charged as indicated. After the switch has been closed, in which circuit (if any) will the charges on the left hand capacitor (i) increase (ii) decrease (iii) remain same ?



(1 remains unchanged, 2 increases, 3 decreases).

12. For what value of C does the equivalent capacitance between A and B is 1μF in the given circuit.



All capacitance given in micro farad **Ans.** 2 μF

13. A pendulum bob of mass 80 mg and carrying charge of 3×10^{-8} C is placed in an horizontal electric field. It comes to equilibrium position at an angle of 37° with the vertical. Calculate the intensity of electric field. ($g = 10 m/s^2$) (2×10^4 N/C)

14. Eight charged water droplets each of radius 1 mm and charge 10×10^{-10} C coalesce to form a single drop. Calculate the potential of the bigger drop.

(3600 V)

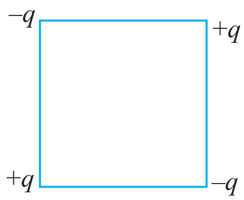
15. What potential difference must be applied to produce an electric field that can accelerate an electron to 1/10 of velocity of light. $(2.6 \times 10^3 \text{ V})$

16. A 10 μF capacitor can withstand a maximum voltage of 100 V across it, whereas another 20 μF capacitor can withstand a maximum voltage of only 25 V. What is the maximum voltage that can be put across their series combination ?

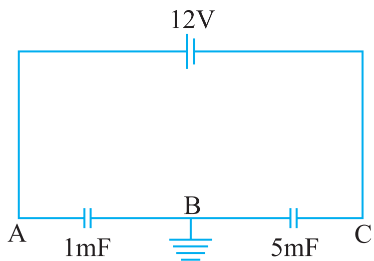
17. Three concentric spherical metallic shells A < B < C of radii *a, b, c* $(a < b < c)$ have surface densities $\sigma, -\sigma$ and σ respectively. Find the potential of three shells A, B and C (ii). If shells A and C are at the same potential obtain relation between *a, b, c*.

18. Four point charges are placed at the corners of the square of edge *a* as shown in the figure. Find the work done in disassembling the system of charges.

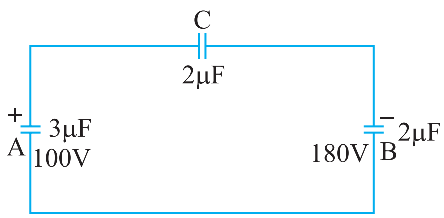
$$\left[\frac{kq^2}{a}(\sqrt{2} - 4)\right] \text{J}$$



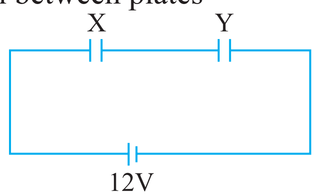
19. Find the potential at A and C in the following circuit :



20. Two capacitors A and B with capacitances 3 μF and 2 μF are charged 100 V and 180 V respectively. The capapitors are connected as shown in the diagram with the uncharged capacitor C. Calculate the (i) final charge on the three capacitors (ii) amount of electrostatic energy stored in the system before and after the completion of the circuit.



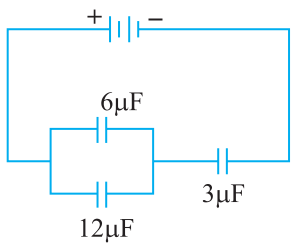
21. Fig. shows two parallel plate capacitors X and Y having same area of plates and same separation between them : X has air while Y has dielectric of constant 4 as medium between plates



(a) calculate capacitance of each capacitor, if equivalent capacitance of combination is 4μF (b) calculate potential difference between plate X and Y (c) what is the ratio of electrostatic energy stored in X & Y.

Ans. (a) 5μF, 20μF, (b) 9.6V, 2.4V (c) 4

22.



In the following arrangement of capacitors, the energy stored in the 6μF capacitor is E.

Find :

(i) Energy stored in 12 μF capacitors.

(ii) Energy stored in 3μF capacitor.

(iii) Total energy drawn from the battery.

Ans. (i) $E = \frac{1}{2}CV^2 = \frac{6}{2} \times 10^{-6}\, V^2 = 3 \times 10^{-6}\, V^2$

$$V^2 = \frac{E}{3 \times 10^{-6}}$$

Energy stored in 12μF capacitor = $\frac{1}{2}CV^2$

$$= \frac{1}{2} \times 12 \times 10^{-6} \times \frac{E}{3 \times 10^{-7}}$$

$$= 2E$$

(ii) Charge on 6μF capacitor $\left[\because E = \frac{1}{2}\frac{Q^2}{C}\right]$

$$Q_1 = \sqrt{2EC}$$

$$= 2\sqrt{3}E \times 10^{-3} C$$

Charge on 12μF capacitor

$$Q_2 = 2\sqrt{2CE}$$

$$= \sqrt{2 \times 12 \times 10^{-6} \times 2E}$$

$$= 4\sqrt{3E} \times 10^{-3} C$$

Charge on 3μF capacitor $Q = Q_1 + Q_2$

$$= 6\sqrt{3E} \times 10^{-3}$$

Energy stored in 3μF capacitor

$$= \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2} \times \frac{36 \times 3E \times 10^{-6}}{3 \times 10^{-6}}$$

$$= 18E$$

(ii) Capacitance of parallel combination = 18μF

Charge on parallel combination Q = CV

$$= 18 \times 10^{-6} V$$

$$\text{Charge on } 3\mu F = Q = 3 \times 10^{-6} V_1$$

$$18 \times 10^{-6} V = 3 \times 10^{-6} V_1$$

$$V_1 = 6V$$

Energy stored in 3μF capacitor = $\frac{1}{2}CV_1^2$

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

$$= 18E$$

(iii) Total eEnergy drawn = E + 2E + 18E = 21E

23. The charge passing through a conductor is a function of time and is given as $q = 2t^2 - 4t + 3$ milli coulomb. Calculate (i) current through the conductor (ii) potential difference across it at $t = 4$ second. Given resistance of conductor is 4 ohm. **Ans.** I = 12A, V = 48 V

24. The resistance of a platinum wire at a point 0°C is 5.00 ohm and its resistance at steam point is 5.40Ω. When the wire is immersed in a hot oil bath, the resistance becomes 5.80Ω. Calculate the temperature of the oil bath and temperature coefficient of resistance of platinum.

Ans. $\alpha = 0.004°\ C^{-1}$; T = 200°C

25. Three identical cells, each of emf 2V and internal resistance 0.2 ohm, are connected in series to an external resistor of 7.4 ohm. Calculate the current in the circuit and the terminal potential difference across an equivalent.

Ans. I = 0.75; V = 5.55 V

26. A storage battery of emf 12V and internal resistance of 1.5Ω is being charged by a 12V supply. How much resistance is to be put in series for charging the battery safely, by maintaining a constant charging current of 6A. **Ans.** R = 16.5 Ω

27. Three cells are connected in parallel, with their like poles connected together, with wires of negligible resistance. If the emf of the cell are 2V, 1V and 4V and if their internal resistance are 4Ω, 3Ω and 2 Ω respectively, find the current through each cell. $\left[\textbf{Ans.}\, I_1 = \frac{-2}{13}A, I_2 = \frac{-7}{13}A,\ I_3 = \frac{9}{13}A\right]$

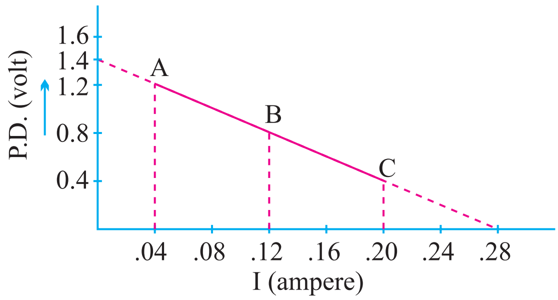
28. A 16 ohm resistance wire is bent to form a square. A source of emf 9 volt is connected across one of its sides. Calculate the potential difference across any one of its diagonals. **Ans.** 1V

29. A length of uniform 'heating wire' made of nichrome has a resistance 72 Ω. At what rate is the energy dissipated if a potential difference of 120V is applied across (a) full length of wire (b) half the length of wire (wire is cut into two). Why is it not advisable to use the half length of wire ?

Ans. (a) 200W, (b) 400W, 400W >> 200W but since current becomes large so it is not advisable to use half the length

30. Potential difference across terminals of a cell are measured (in volt) against different current (in ampere) flowing through the cell. A graph was drawn which was a straight line ABC. Using the data given in the graph. Determine (i) the emf. (ii) The internal resistance of the cell.

Ans. $r = 5\Omega$ emf = 1.4V

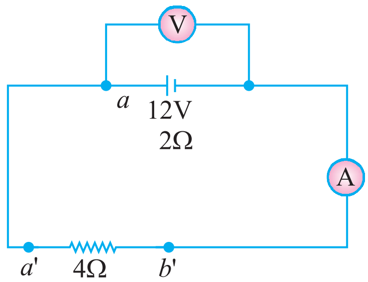


31. Four cells each of internal resistance 0.8Ω and emf 1.4V, are connected (i) in series (ii) in parallel. The terminals of the battery are joined to the lamp of resistance 10Ω. Find the current through the lamp and each cell in both the cases.

Ans. $I_s = 0.424A$, $I_p = 0.137A$ current through each cell is 0.03A

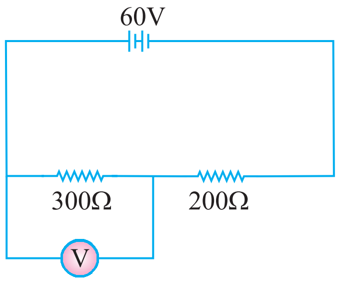
32. In the figure, an ammeter A and a resistor of resistance R = 4Ω have been connected to the terminals of the source to form a complete circuit. The emf of the source is 12V having an internal resistance of 2Ω. Calculate voltmeter and ammeter reading.

Ans. Voltmeter reading : 8V, Ammeter reading = 2A

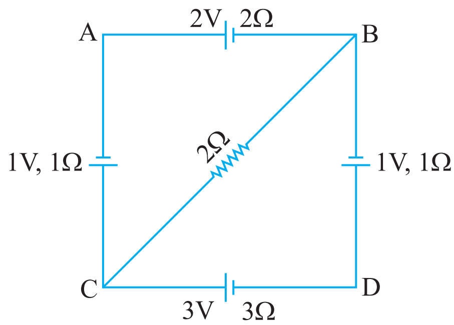


33. In the circuit shown, the reading of voltmeter is 20V. Calculate resistance of voltmeter. What will be the reading of voltmeter if this is put across 200Ω resistance ?

$\left[\textbf{Ans. } R_V = 150\Omega,\ V = \frac{40}{3}V\right]$



34. For the circuit given below, find the potential difference b/w points B and D. **Ans.** 1.46 Volts

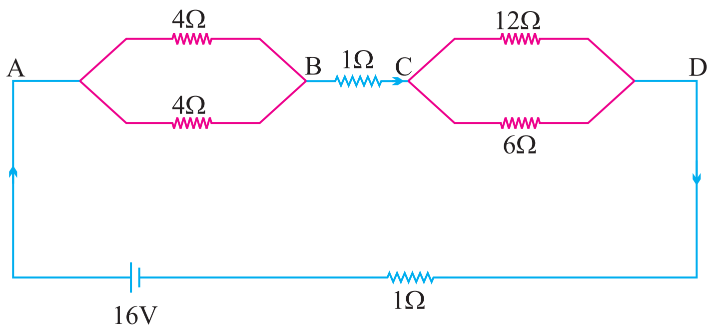


35. A battery of emf 10V and internal resistance 3Ω is connected to a resistor. If the current in the circuit is 0.5A, what is the resistance of the resistor ? What is the terminal voltage of the battery when the circuit is closed ?

36. A network of resistance is connected to a 16V battery with internal resistance of 1Ω as shown in Fig. on next page.

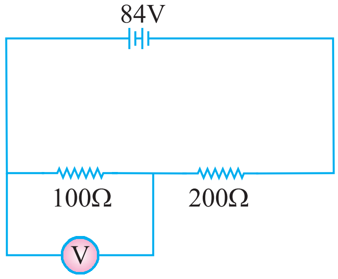
(i) Obtain the current in each resistor.

(ii) Obtain the voltage drop V_{AB}, V_{BC} & V_{CD}.

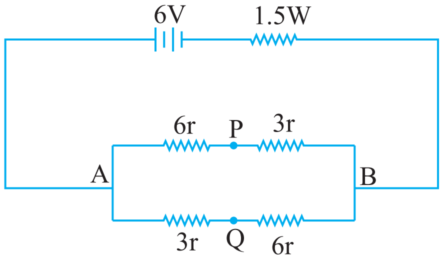


37. The number density of conduction electrons in a Copper Conductor estimated to be 8.5×10^{28} m^{-3}. How long does an electron take to drift from one end of a wire 3.0 m long to its other end ? The area of cross section of the wire is 2.0×10^{-6} m^2 and it is carrying a current of 3.0 A.

38. A voltmeter of resistance 400Ω is used to measure the potential difference across the 100Ω resistor in the circuit shown in figure. What will be the reading of voltmeter.



39. Find magnitude of current supplied by battery. Also find potential difference between points P and Q in the given fig. **Ans.**1A, 1.5V



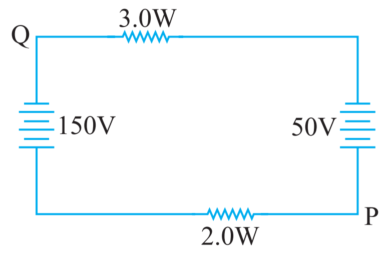
40. A copper wire of length 3 m and radius r is nickel plated till its radius becomes $2r$. What would be the effective resistance of the wire, if specific resistance of copper and nickel are ρ_c and ρ_n respectively.

[Hint : $R_c = \rho_c \dfrac{l}{\pi r^2}$; $R_n = \rho_n \dfrac{l}{\pi(2r)^2 - \pi r^2}$

$$R = \frac{R_C R_n}{R_C + R_n}.$$

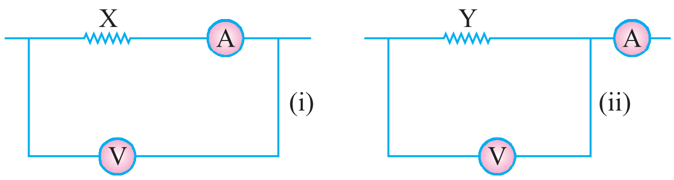
$$\left[\textbf{Ans. } R = \frac{3\rho_n \rho_c}{\pi r^2 (3\rho_c + \rho_n)}\right]$$

41. In the figure, if the potential at point P is 100V, what is the potential at point Q ?



Ans. – 10V

42. Given two resistors X and Y whose resistances are to be determined using an ammeter of resistance 0.5Ω and a voltmeter of resistance 20 kΩ. It is known that X is in the range of a few ohms, while Y is in the range of several thousand ohm. In each case, which of the two connection shown should be chosen for resistance measurement ?

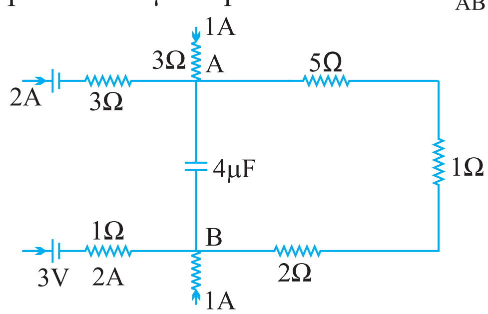


Ans. Small resistance : X will be preferred; large resistance : Y will be preferred

43. When resistance of 2Ω is connected across the terminals of a battery, the current is 0.5A. When the resistance across the terminal is 5Ω, the current is 0.25A. (i) Determine the emf of the battery (ii) What will be current drawn from the cell when it is short circuited.

Ans. E = 1.5 V, I = 1.5A

44. A part of a circuit in steady state, along with the currents flowing in the branches and the resistances, is shown in the figure. Calculate energy stored in the capacitor of 4μF capacitance. **Ans.** $V_{AB} = 20V$, $U = 8 \times 10^{-4}$ J

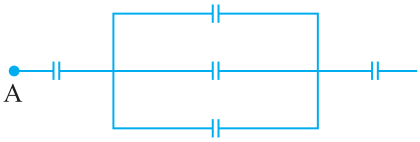


45. A voltmeter with resistance 500Ω is used to measure the emf of a cell of internal resistance 4Ω. What will be the percentage error in the reading of the voltmeter. **Ans.** 0.8%

HINTS FOR 2 MARKS QUESTIONS

10. $\dfrac{t_e}{t_p} = \sqrt{\dfrac{2sm_e}{eE}} \Big/ \sqrt{\dfrac{2sm_p}{eE}} = \sqrt{\dfrac{m_e}{m_p}}$

14.



$$\frac{1}{Cs} = \frac{1}{2} + \frac{1}{6} + \frac{1}{2} = \frac{1}{6}$$

$$Cs = \frac{6}{7}\ \mu F$$

21. $\varphi = \bar{E}.\bar{ds} = 2x\hat{i}.ds\hat{i} = 2x.ds$

$\varphi_1 = 0$, $\varphi_2 = 50$ Vm, $\varphi_3 = 150$ Vm

28. $W_{BA} = q_o\ (V_B - V_A) = 2 \times 1000 = 2000$ J

32. In the capacitor the voltage increases from O to V, hence energy stored will correspond to average which will be ½ QV. While the source is at constant emf V. So energy supplied will be QV. The difference between the two goes as heat and emf radiations.

35. Construct a closed system such that charge is enclosed within it. For the charge on one face, we need to have two cubes place such that charge is on the common face. According to Gauss's theorem total flux through the Gaussian surface (both cubes) is equal to $\dfrac{q}{2\varepsilon_0}$. Therefore the flux through one cube will be equal to $\dfrac{q}{2\varepsilon_0}$.

36. Work done $= fd \cos\theta = qEd \cos\theta = \dfrac{q(\sigma_1 - \sigma_2)}{\varepsilon_0}\dfrac{a}{\sqrt{2}}$

40. $\frac{R_1}{R_2} = \frac{l I_1}{A_1} \times \frac{A_2}{l I_2} \Rightarrow \frac{I_1 A_2}{A_1 I_2} \Rightarrow \frac{1}{2}, \frac{I_1}{I_2} = \frac{1}{2} \therefore \frac{A_2}{A_1} = 1$

(i) in series neA, $(V_d) = neA_2(V_d)_2 \Rightarrow \frac{(V_d)_1}{(V_d)_2} = 1$

(ii) $i_1 R_1 = i_2 R_2 \Rightarrow \frac{(V_d)_1}{(V_d)_2} = \frac{2}{1}$

42. Current through $5\Omega = \left(\frac{10}{5+10}\right) I = \frac{2I}{3}$

56. $I = \frac{\text{Charge circulating}}{\text{Time for one revolution}} = \frac{e}{2\pi r / v}$ $\qquad v \longrightarrow$ speed

$$= \frac{ev}{2\pi r}$$

$$= \frac{ee^2me^2}{n2\pi n^2} = \frac{me^5}{2\pi n^3}$$

57. In steady state the branch containing C can be omitted hence the current

$$I = \frac{2V - V}{R + 2R} = \frac{V}{3R}$$

For loop EBCDE

$$-V_C - V + 2V - 1\,(2R) = 0$$

$\Rightarrow$ $$V_C = \frac{V}{3}$$

$$\frac{V}{l}$$

51. Milliammeter. To produce large deflection due to small current we need a large number of turns in armature coil $\Rightarrow$ Resistance increases.

52. Temperature

53. The electron number density is of the order of $10^{29}\ m^{-3}$, $\Rightarrow$ the net current can be very high even if the drift spread is low.

54. $$V = E + ir$$
$$= 2 + 0.15$$
$$= 2.15V$$

HINTS FOR NUMERICALS

9. $$V = E_o\left(\frac{d}{4}\right) + \frac{E_o}{K}\left(\frac{3d}{4}\right) = E_o\, d\left(\frac{K+3}{4K}\right)$$

$$V = V_o\left(\frac{K+3}{4K}\right)$$

$$C = \frac{Q_o}{V} = \frac{4K}{K+3}\frac{Q_o}{V_o} = \frac{4K}{K+3}Co$$

14. $$r = 1 \text{ mm}$$

$$\frac{4}{3}\pi R^3 = 8 \cdot \frac{4}{3}\pi r^3 \Rightarrow R = 2 \text{ mm}$$

$$Q = 8q = 8 \times 10 \times 10^{-10}\text{ C}$$

$$V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{R}$$

$$= \frac{9 \times 10^9 \times 8 \times 10^{-9}}{2 \times 10^{-3}} = 36000 \text{ Volt}$$

21. $$C_x = C,\ C_y = KC = 4C$$

$$\frac{C_x C_y}{C_x + C_y} = \frac{4}{5}C = 4 \Rightarrow C = 5\mu f$$

(a) $$Ceq\ = C_x = 5\mu f$$

$$C_y = 20\mu f$$

(b) $$V + \frac{V}{4} = 12\ (V_x = V,\ V_y = \frac{V}{4} \text{ as } q \text{ constant})$$

$$V = 9.6 \text{ Volt},\ V_x = 9.6 \text{ Volt},\ V_y = 2.4 \text{ Volt}$$

(c) $$\frac{U_x}{U_y} = \frac{\frac{1}{2}C_x V_{x^2}}{\frac{1}{2}C_y (V_y)^2} = 4$$

HINTS FOR 3 MARKS QUESTIONS

16. If E′ be the electric field due to each plate (of large dimensions) then net electric field between them

$$E = E' + E' \Rightarrow E' = E/2$$

Force on change Q at some point between the plates F = QE

Force on one plate of the capacitor due to another plate F′ = QE′ = QE/2

17.

$$V_1 = \frac{kq}{r} + \frac{kq}{6r} = \frac{7kq}{6r}$$

$$V_2 = \frac{kq}{2r} + \frac{kq}{6r} = \frac{3kq + kq}{6r} = \frac{4kq}{6r}$$

$$\frac{V_1}{V_2} = \frac{7}{4}$$

$$V_{common} = \frac{2q}{4\pi\varepsilon_0(r + 2r)} = \frac{2q}{12\pi\varepsilon_0 r} = V'$$

Charge transferred equal to

$$q' = C_1V_1 - C_1V' = \frac{r}{k}.\frac{kq}{r} - \frac{r}{k}.\frac{k_2q}{3r}$$

$$= q - \frac{2q}{3} = \frac{q}{3}.$$

27.

$$R_1 = \frac{V_1}{I_1} = \frac{50}{2 \times 10^{-3}} = 25{,}000\Omega$$

$$R_2 = \frac{V_2}{I_2} = \frac{60}{3 \times 10^{-3}} = 20{,}000\Omega.$$

As resistance changes with I, therefore conductor is non ohmic.

28. Rate of production of heat, $P = I^2R$, for given l, P × R, ∴ $\rho_{nichrome} > \rho_{cu}$

∴ $R_{Nichrome} > R_{cu}$ of same length and area of cross section.

29. (i) If I in circuit is constant because $H = I^2 Rt$

(ii) If V in circuit is constant because $H = \frac{V^2}{R}t$

NUMERICALS

17. $$V_A = k\left[\frac{q_1}{a} + \frac{q_2}{b} + \frac{q_3}{c}\right]$$

$$= k\,4\pi a\sigma - k4\pi b\sigma + k4\pi c\sigma$$

$$= 4\pi a\sigma\,(a - b + c)$$

$$= \frac{\sigma}{\varepsilon_0}(a - b + c)$$

$$V_B = k\left[\frac{q_1}{b} + \frac{q_2}{b} + \frac{q_3}{c}\right] = k\left[\frac{4\pi a^2\sigma}{b} - 4\pi kb\sigma + 4\pi kc\sigma\right]$$

$$= \frac{\sigma}{\varepsilon_0}\left(\frac{a^2}{b} - b^2 + c^2\right)$$

$$V_C = \frac{\sigma}{\varepsilon_0 c}(a^2 - b^2 + c^2)$$

When $V_A = V_C$

$$\frac{\sigma}{\varepsilon_0}(a - b + c) = \frac{\sigma}{\varepsilon_0 C}(a^2 - b^2 + c^2)$$

$$ac - bc + c^2 = a^2 - b^2 + c^2$$

$$c\,(a - b) = (a - b)\,(a + b)$$

$$c = a + b$$

19. $$Q = CV$$

Total charge Q = Total capacitance in series × voltage

$$= \left(\frac{5}{6} \times 10^{-3}\right) \times 12 = 10 \times 10^{-3} \text{ coulomb}$$

$$V_{AB} = \frac{Q}{c_1} = \frac{10 \times 10^{-3}}{1 \times 10^{-3}} = 10\text{V}$$

$$V_{BC} = \frac{Q}{c_2} = \frac{10 \times 10^{-3}}{5 \times 10^{-3}} = 2\text{V.}$$

When B is earthed $V_B = 0$, $V_A = 10V$ and $V_C = -2V$.

21. Before dielectric is introduced.

$$E_A = \frac{1}{2}CV^2; \qquad E_B = \frac{1}{2}CV^2$$

$$E = E_A + E_B = CV^2$$

After disconnecting the battery and then introducing dielectric

$$E'_A = \frac{1}{2}(3C)V^2$$

$$E'_B = \frac{Q^2}{2C} = \frac{(CV)^2}{2\times 3C}$$

$$= \frac{1}{3}\left(\frac{1}{2}CV^2\right),$$

$$E' = E'_A + E'_B$$

$$\frac{E'}{E} = \frac{5}{3}.$$

35.

$$E = I(R + r)$$

$$10 = 0.5\ (R + 3)$$

$$R = 17\Omega$$

$$V = E - Ir = 10 - 0.5 \times 3 = 8.5V$$

36.

$$Req = 7W$$

$$I_{4\Omega} = 1A, I_{1\Omega} = 2A, I_{12\Omega} = \frac{2}{3}A, I_{6\Omega} = \frac{4}{3}A,$$

$$V_{AB} = 4V, V_{BC} = 2V, V_{CD} = 8V$$

37. $$I = enAV_d = \frac{l}{t}$$

$$t = \frac{en\,Al}{1} = 2.7 \times 10^4 \text{ s}$$

38. $$I = \frac{84}{\left(\frac{100 \times 400}{100 + 400}\right) + 200} = \frac{84}{280} = 0.3A$$

P.d. across voltmeter & 100Ω combination

$$= 0.3 \times \frac{100 \times 400}{100 + 400} = 24V.$$

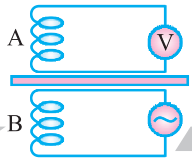
39. $$R_{AB} = 4.5\Omega$$

$$i = \frac{E}{R_{AB} + 1.5} = \frac{6}{6} = 1A.$$

$$i_{AP} = i_{AQ} = 0.5A, V_{AP} = 3 \Rightarrow V_p = 3 \text{ Volt}$$

$$V_{AQ} = 1.5\ V_Q = 4.5 \text{ Volt}$$

$$V_Q - V_P = 1.5 \text{ Volt}$$



Unit III and IV

Section - 2

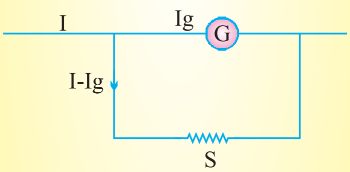
KEY POINTS

Physical Quantity	Formulae	SI Unit
Biot-Savart's Law	$d\vec{B} = \dfrac{\mu_0}{4\pi}\dfrac{Id\vec{l}\times\vec{r}}{r^3}$	Tesla (T);
	$\lvert d\vec{B}\rvert = \dfrac{\mu_0}{4\pi}\dfrac{Idl\sin\theta}{r^2}$	10^4 Gauss = 1T
Magnetic field due to a straight current carrying conductor	$B = \dfrac{\mu_0 I}{2\pi R}$	T
Magnetic field at the centre of	$B = \dfrac{\mu_0 I}{2a}$	T
a circular loop	$B = \dfrac{\mu_0 nI}{2a}$ (For n loops)	
Magnetic Field at a Point on the Axis of a current carrying loop	$B = \dfrac{\mu_0 I}{4\pi}\dfrac{2\pi a^2}{\left(a^2+x^2\right)^{\frac{3}{2}}}$	T
	When, $x = 0$, $B = \dfrac{\mu_0 I}{2a}$	
	For $a << x$, $B = \dfrac{\mu_0 I a^2}{2x^3}$	
	For n loops, $B = \dfrac{\mu_0 n I a}{2x^3}$	
Ampere's Circuital Law	$\oint \vec{B}.d\vec{l} = \mu_0 I$	T – m

Magnetic field due to a long straight solenoid	$B = \mu_0 n I$ At the end of solenoid, $B = \frac{1}{2} \mu_0 n I$ If solenoid is filled with material having magnetic permeability μr $B = \mu_0 \mu_r \, n I$	T
Magnetic field due to a toroidal solenoid	$B = \mu_0 \, n I$	T
Motion of a charged particle inside electric field	$y = \frac{qE}{2m}\left(\frac{x}{v_x}\right)^2$	m
Megnetic force on a moving charge	$\vec{F} = q\left(\overline{v} \times \vec{B}\right)$ Or $F = qv \, B \sin \theta$	N
Lorentz Force (Electric and Magnetic)	$\vec{F} = q\vec{E} + q\left(\overline{v} \times \vec{B}\right)$	N
The Cyclotron		
Radius of circular path	$r = \frac{mv}{Bq}$	
The period of circular motion	$T = \frac{2\pi m}{Bq}$	
The cyclotron frequency	$v = \frac{1}{T} = \frac{Bq}{2\pi m}$	
Maximum energy of the positive ions	$\frac{1}{2} m v_{max}^2 = \frac{B^2 q^2 r^2}{2m} = qV = qV$	
The radius corresponding to maximum velocity	$r = \frac{1}{B}\left(\frac{2mV}{q}\right)^{\frac{1}{2}}$	

The maximum velocity	$V_{max} = \frac{Bqr}{m}$	
The radius of helical path when $\overline{v}$ and $\vec{B}$ are inclined to each other by an angle θ	$r = \frac{mv \sin\theta}{qB}$	
Force on a current carrying conductor placed in a magnetic field	$\vec{F} = I\left(\vec{l} \times \vec{B}\right)$	N
Force per unit length betwen two parallel current carrying conductors	$f = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{r}$	Nm^{-1}
Magnetic dipole moment	$\vec{M} = I\vec{A}$	Am^2 or JT^{-1}
Torque on a rectangular current carrying loop ABCD	$\vec{\tau} = \vec{M} \times \vec{B}$ $\Rightarrow \tau = MB \sin\alpha$ If coil has n turns, $\tau = n\ B\ I\ A \sin\alpha$ $\alpha \rightarrow$ angle between normal drawn on the plane of loop and magnetic field	
Period of oscillation of bar magnet if external magnetic field	$T = 2\pi\sqrt{\frac{I}{MB}}$	S
The potential energy associated with magnetic field	$U = -\ \vec{M}\cdot\vec{B} = -\ MB \cos\theta$	
Current through a galvanometer $\phi \rightarrow$ angle by which the coil rotates	$I = \frac{k}{nBA}\phi = G\phi;$ $G \rightarrow$galvanometer constant	A

Sensitivity of a galvanometer or		
Current sensitivity	$I_s = \frac{\theta}{I} - \frac{nBA}{k} = \frac{1}{G}$	rad A^{-1}
Voltage sensitivity	$V_s = \frac{\theta}{V} = \frac{nBA}{kR} = \frac{1}{GR}$	rad V^{-1}
The current loop as a magnetic	$B = \frac{\mu_0}{4\pi}\frac{2M}{x^3}$ T	
dipole on axis at very large distance from the centre		
Gyromagnetic ratio	$\frac{\mu_e}{L} = \frac{e}{2m_e} = 8.8 \times 10^{10}\ \frac{C}{kg}$ $\rightarrow$ Angular momentum	C Kg^{-1}
Bohr magneton	$(\mu_e)_{min} = \frac{e}{4\pi m_e}h$	Am^2
	$= 9.27 \times 10^{-24}$	
Magnetic dipole moment	$\vec{M} = m\left(2\vec{l}\right)$	JT^{-1} or Am^2
Magnetic field on axial line of a bar magnet	$B_{axial} = \frac{\mu_0}{4\pi}\left[\frac{2Mr}{(r^2 - l^2)^2}\right]$ When, $l << r$, $B_{eq} = \frac{\mu_0}{4\pi}\frac{M}{r^3}$	T
Gauss's Law in magnetism	$\oint_S \vec{B}.d\vec{S} = 0$	Tm^2 or weber
Magnetic inclination (or Dip)	$\tan\delta = \frac{B_V}{B_H}$, $\delta \rightarrow$ angle of dip	
Magnetic intensity (or Magnetic	$H = \frac{B_0}{\mu_0} = nI$	Am^{-1}
field strength)	n is the no. of	terms/length
Intensity of magnetization	$I_m = \frac{M}{V}$	Am^{-1}

Magnetic flux	$\phi = \vec{B}.\Delta\vec{S}$	Weber or Tm^2
Magnetic induction (or Magnetic flux density or Magnetic field)	$B = B_0 + \mu_0 I_m$ $= \mu_0 (H + I_m)$	T
Magnetic susceptibility	$\chi_m = \dfrac{I_m}{H}$ —	
Magnetic permeability	$\mu = \dfrac{B}{H}$ TmA^{-1} (or NA^{-2})	
Relative permeability (μ)	$\dfrac{\mu}{\mu_0} = \mu_r = (1+\chi_m)$	
Curie's Law	$\chi_m = \dfrac{C}{T}$, C $\rightarrow$ curie constant	
Conversion of a Galvanometer into Ammeter 	$IgG = (I - Ig)S$ $Ig(G+S) = SI$ $Ig = \left(\dfrac{S}{G+S}\right)I$ S $\rightarrow$ shunt resistance	
Conversion of a Galvanometer into voltmeter  $R = \dfrac{V}{Ig} - G$	G $\rightarrow$ Galvanometer resistance	

UNIT–III & UNIT–IV

MAGNETIC EFFECTS OF CURRENT AND MAGNETISM
&
E.M.I. AND ALTERNATING CURRENT

QUESTIONS

SECTION - A

VERY SHORT ANSWER QUESTIONS (1 Mark)

MULTIPLE CHOICE QUESTIONS (1 MARK)

1. The force per unit length between two, long current carrying conductors is F. If the current in each conductor is doubled and distance between theme is halved, what wil be the new force per unit length between them?

   (a) 2F (b) F
   (c) 8F (d) 16 F

2. The magnetic susceptibility of magnetic materials A and B are – 0.085 and 0.9853 respectively, then

   (a) A is diamagnetic and B is paramagnetic
   (b) A is paramagnetic and B is ferromagnetic
   (c) A is paramagnetic and B is diamagnetic
   (d) A is ferromagnetic and B is diamagnetic

3. An electron is moving along. the positive x-axis as in a uniform magnetic field along positive y-axis. The Lorentz force will act along

   (a) positive z-axis (b) negative z-axis
   (C) positive y-axis (d) negative y-axis

4. The magnetic moment of a circular coil of radius & carrying current I having number of turne N is

(a) NIR^2 (b) $\frac{NI}{r^2}$

(c) πNIr^2 (d) $\frac{NI}{\pi r^2}$

5. A proton and an α-particle enters in uniform magnetic field normal to direction of filed having same momenta. The ratio of radii of their circular path is

(a) 1:1 (b) 1:2

(c) 2: 1 (d) 1:4

6. An election is projected with unifrom velocity along the axis of a current carrying straight solenoid. Which of the following is true?

(a) The electron will move on a circular path about the axis of selencid

(b) The election will accelerate along the axis of selenoid

(c) The election will move on a helical path

(d) The electron will continue to move with uniform velocity along the axis of solenoid

7. If a charged particle moves through a magnetic field perpendicular to it, then

(a) Both momentum and kinetic energy are constant

(b) Momentum changes but kinetic energy remains constant

(c) Momentum remains constant but kinetic energy changes

(d) Both momentum and kinetic energy changes

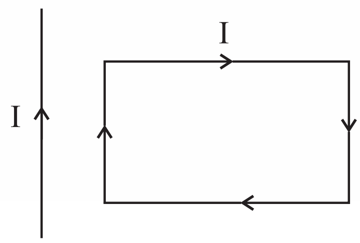
8. A rectangular loop carrying a current I is situated near a long straight wire such that the long wire is parallel to one of the sides of the loop and is in the plane of the loop. If a steady current I flows in the wire as shown in figure, then the loop will

(a) move towards the wire

(b) move away from the wire

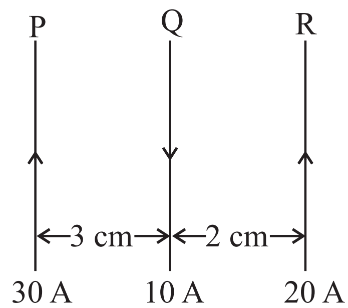
(c) remain stationary

(d) rotate about the wire



9. A current loop placed in a non-uniform magnetic field experiences
   (a) a net force but not torque
   (b) a torque but no net force
   (c) neither a net force nor a torque
   (d) a net force and a torque both

10. Three long straight parallel wires, carrying currents are arranged as shown in the figure. The force experienced by 10 cm length of wire Q is
    (a) 2×10^{-4} N (b) 4×10^{-4} N
    (c) 3×10^{-4} N (d) Zero

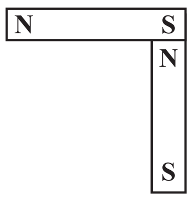


11. The current sensitivity of a moving coil galvanometer increases with decrease in
    (a) Number of turns (b) magnetic field
    (c) Area of the coil (d) None of these

12. The relative permeability of paramagnetic substance is
    (a) Less than unity (b) More than unity but small
    (c) Very large (d) negative and small

13. A power line carries current from west to east. The direction of magnetic field 2m above it is
    (a) Towards east (b) Towards west
    (c) Towards north (d) Towards south

14. Two identical bar magnets each of magnetic movement m are placed perpendicular to each other as shown in the figure. The net magnetic moment of combination is
    (a) m (b) 2m
    (c) $\sqrt{2}$ m (d) $\frac{m}{\sqrt{2}}$



15. A charged particle when enters normal to uniform magnetic field, it moves on a circular path, The angular frequency of this motion is independent of

(a) Charge (b) Magnetic field

(c) Velocity (d) Mass

Answer Key

1. (c) 8 F
2. (a) A is diamagnetic and B is paramagnetic
3. (b) Negative Z-axis
4. (c) πNIr^2
5. (c) 2 : 1
6. (a) The electron will continue to move with uniform velocity along the axis of solenoid.
7. (b) Momentum changes but Kinetic energy remains constant
8. (a) Move towards the wire
9. (d) a net force and a torque both
10. (d) zero
11. (d) none of these
12. (b) More than unity but small
13. (d) towards south
14. (c) $\sqrt{2}$ m
15. (c) Velocity

Multiple Choice Questions

Chapter-5 Magnetism and Matter

16. Ni shows ferromagnetic property at rom temperature. If heated to very high temperature. You would expect it to show:

(a) Ferromagnetism (b) Diamagnetism

(c) Paramagnetism (d) None of these

17. The surest test of magnetism is -

(a) Attraction (b) No force

(c) Repulsion

(d) Attraction towards centre of earth

18. If a bar magnet is cut into two pieces along its length, then mangetic moment (M') will be __________ of initial magnetic moment (M).

(a) Equal (b) Half

(c) Twice (d) Thirce

19. Magnetic susceptibility is negative for-

(a) Ferromanetic materials (b) Diamagnetic materials

(c) Paramagnetic materials (d) Nonmagnetic materials

20. A short barmagnet with its aixs at 30° with a uniform magnetic field of 160 gauss, has magnetic moment 4 Am^2. Torque experienced by bar magnet will be-

(a) 0.15 Nm (b) 1.0 Nm

(c) 2.0 Nm (d) 0.032 Nm

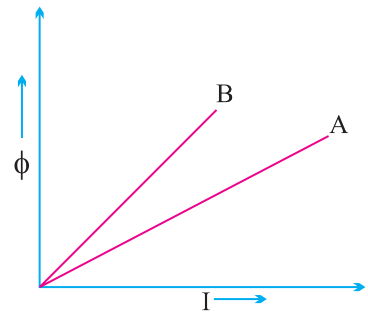
Answers

16. (c) 17. (c) 18. (b) 19. (b)

20. (d)

Chapter-6 ELectromagnetic Induction

21. A plot of magnetic flux (ϕ) versus current (I) is shown in figure for two inductors A and B. Which of the two has larger value of self inductance?



(a) A (b) B

(c) Both have equal values (d) Value can not be determined

22. A pair of adjacent coil has a mutual inductance 1.5H. It the current in one coil changes from 0 to 20 A in 0.5s, what the flux linkage with the other coil?

(a) 40 weber (b) 50 weber

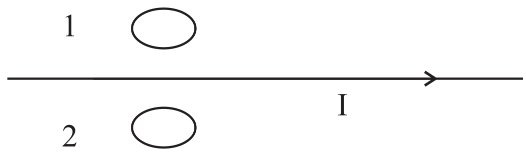
(c) 30 weber (d) 20 weber

23. Two loops are lying on the table without touching each other. Loop A carries a current which is increasing with time. In response, loop B would –

(a) remains at rest (b) be attracted to A

(c) be repelled by A (d) rotate about the vertical axis

24. Find the direction of induced currents in metal ring 1 and 2 lying in the same plane where current I in the wire increasing steadily.



(a) $1 \rightarrow$ clockwise
$2 \rightarrow$ clockwise

(b $1 \rightarrow$ Anticlockwise
$2 \rightarrow$ Anticlockwise

(c) $1 \rightarrow$ clockwise
$2 \rightarrow$ Anticlockwise

(b $1 \rightarrow$ Anticlockwise
$2 \rightarrow$ clockwise

25. The currents flowing in the two coils of self inductance L_1 = 16mH and L_2 = 12mH are increasing at the same rate. If the power supplied to the two coils are equal, the ratio of the currents will be—

(a) 3 : 4
(b) 4 : 3
(c) 5 : 4
(d) 4 : 5

Answers:

Q	21	22	23	24	25
Ans.	a	c	c	c	a

Chapter - 7 ALternatting Current MCQ

26. Resonance occurs in a series L – C – R circuit when –

(a) $X_L > X_C$
(b) $X_L < X_C$
(c) $X_L = 0$
(d) $X_L = X_C$

27. At resonance in series L–C–R circuit, which relation does not hold?

(a) $w = \frac{1}{\sqrt{LC}}$
(b) $Lw = \frac{1}{C\omega}$
(c) $w = \frac{1}{LC}$
(d) $C\omega = \frac{1}{Lw}$

28. Peak value of AC at 220 V is—

(a) 311 V (b) 210 V

(c) 225 V (d) 399 V

29. The relation between the rms value (I_{rms}) and peak value (I_0) of A.C is—

(a) $\frac{\sqrt{2}}{I_0}$ (b) 2.5 I_0

(c) 0.637 I_0 (d) 0.707 I_0

30. Value of capacitive reactance (Xc) in DC circuit will be

(a) 0Ω (b) ∞

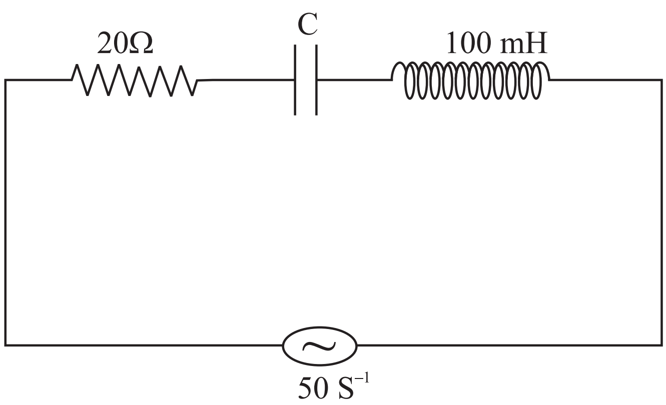
(c) 1Ω (d) 100 Ω

31. One 2 ohm resistor is connected in series with an inductor of reactance 1Ω to a 5V (rms) AC source. Impedance of the ciruit is—

(a) 3Ω (b) $\sqrt{5}$ Ω

(c) 5 Ω (d) $\sqrt{3}$ Ω

32. In a series LCR circuit shown below, the power factor is unity.



The Capacitance C of the capacitor will be -

(a) 205 μF (b) 95 μF

(c) 100 4F (d) 309μF

33. If the frequency of ac source is increased, the current through capacitor will be

(a) Inereased (b) decreased

(c) zero (d) same

34. Which of the following relations holds true in case of a transformer having turus N_1, and N_2, Voltage V_1 & V_2 and comment I_1, and I_2 in primary and secondary coils respectively?

(a) $\frac{V_1}{V_2} = \frac{N_1}{N_2}$ (b) $\frac{I_1}{V_1} = \frac{N_1}{N_2}$

(c) $\frac{V_2}{V_1} = \frac{N_1}{N_2}$ (d) $\frac{I_1}{I_2} = \frac{N_1}{N_2}$

35. In an a.c generator, 'X' is a rectangular coil made up of a large number of turns of copper wire coiled around a soft iron core. Determine the identity of 'X'.

(a) slip ring (b) Armature

(c) copper brushes (d) Field magnet

Answers

Q	26	27	28	29	30	31	32	33	34	35
A	d	c	a	d	b	b	c	a	a	b

ASSERTION AND REASONS : (UNIT III)

In the following questions, a statement of assertion A is followed by a statement of reason R. Mark the correct choice as :

a) If both assertion and reason are correct and reason is the correct explanation of assertion.

b) If both assertion and reason are correct but reason is not the correct explanation of assertion.

c) If assertion is true but reason is false.

d) If both assertion and reason are false.

1. Assertion : If a proton and an alpha particle enters in a uniform magnetic field perpendicularly with equal momentum then proton has larger radius of curve than that of alpha particle.

   Reason : Proton has less mass than alpha particle.

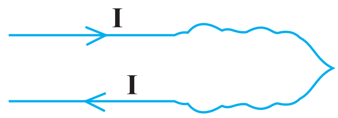
   (Ans. b)

2. Assertion : Magnetic field cannot change the kinetic energy of the charged particle.

   Reason : Magnetic field can not change the velocity of the particle

3. Assertion : A wire is bent as shown in figure.

A currant I is passed through it, if currant has some significant value the area of wire irregular shape will be increased.



Reason : Parallel currents carrying wire REPEL each other.

(Ans. c)

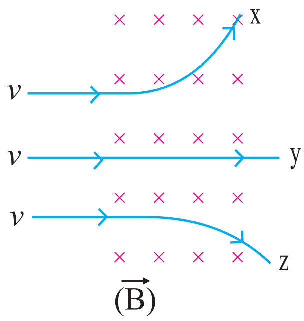
4 Assertion : Magnetic field shows effect of force on moving charge but not on charges at rest.

Reason : Moving charges creates magnetic field.

(Ans. a)

5. Assertion : In the given diagram particle 'X' has highest $\frac{q}{m}$ value.

Reason : The radius acquired by any charged particle in uniform magnetic field is inversely proportional to $\frac{q}{m}$ value.



(Ans. a)

ASSERTION AND REASONS : (UNIT IV)

In the following questions, a statement of assertion A is followed by a statement of reason R mark the correct choice as :

a) If both assertion and reason are correct and reason is the correct explanation of assertion.

b) If both assertion and reason are correct but reason is not the correct explanation of assertion.

c) If assertion is true but reason is false.

d) If both assertion and reason are false.

1. Assertion : If the frequency of the applied A.C. is doubled, then power factor of RC circuit is increase.

Reason : For pure resistive circuit power factor is 1 (unity)

(Ans. b)

2. Assertion : The quantity R/L possesses the dimension of frequency.

   Reason : At resonance the current in the A.C. circuit is zero.

   (Ans. c)

3. Assertion : It is advantageous to transmit electric power at high current.

   Reason : High current implies high voltage.

   (Ans. d)

4. Assertion : While keeping area of cross-section of a solenoid same, the number of turns and length of solenoid are both doubled, the self inductance of the coil will be doubled.

   Reason : Self inductance of a coil can be expressed as $\frac{\mu_0 N^2 A}{l}$

   (Ans. a)

5. Assertion : An emf is induced is a closed loop where magnetic flux is varied. The induced $\vec{E}$ in not a conservative field.

   Reason : $\oint \overline{E}.d\vec{i} \neq o$

   (Ans. a)

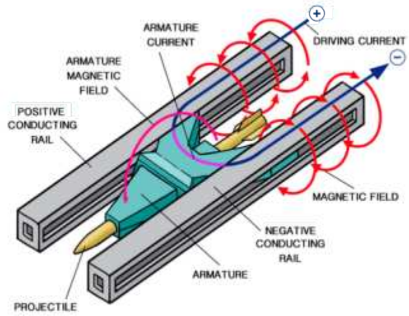
SECTION - B

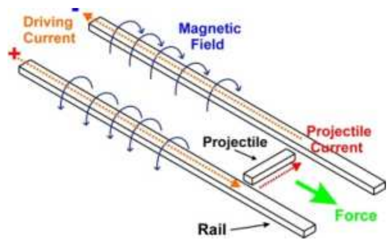
(UNIT : III)

Case Study

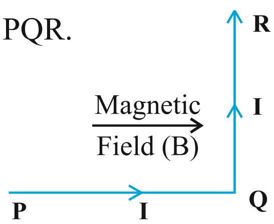
1. Rail Gun

The basic of Rail Gun is as shown in figure. A large current is sent along one of two parallel conducting rails, across a conducting "fuse" (such as a narrow piece of copper) between the rails and then back to the current source along the second rail. The projectile to be fired lies on the for side of the fuse and fits loosely between the rails. Immediately after the current begins, the fuse element melts and vaporises, creating a gas between the rails where by rails in downward direction between the rails. Thus bu $\vec{F}=I\vec{l}\ x\ \vec{B}$, Force $\vec{F}$ on gas due to current I will be outward direction. As the gas forced outward along the rails, it pushes the projectile (about 3-5 km/s) within 1 ms. Rail guns have been researched as weapons utilising electromagnetic forces to impart a very high kinetic energy to a projectile.





1. A wire PQR is bent as shown in figure placed in uniform magnetic field B. PQ=QR=l. Current I is flowing along PQR.



The magnitude of force on PQ and QR will be

a) BIL,o   d) 2 Bil,o   c) BIl   d) o,v

2. In a rail gun if the current in each rail will be increased to vary value, then

   a) The attraction between the rails will be increased.

   b) The repulsion between the rails will be increased.

   c) Force between the rails in independent of current.

   d) None of the above.

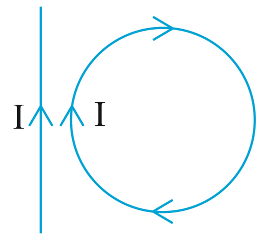
3. In the given figure the loop is fixed but straight wire can move. The straight wire will

   a) Remain stationary

   b) Move towards the loop

   c) Move away from rule

   d) Rotate about its axis



4. Two long straight wires are set parallel to each other. Each carries a current 'i' in the same direction and separation between them is '2r'. Intensity of magnetic field mid way between them is.

   a) $\frac{\mu_0 i}{r}$ b) zero c) $\frac{\mu_0 I}{r}$ d) $\frac{\mu_0 I}{4r}$

5. If a long hollow copper wire carries a current the magnetic field produced will be

   a) Inside the pipe only.

   b) Outside the pipe only.

   c) Neither inside nor outside the pipe.

   d) Both inside and outside the pipe.

Answers :

1 c)

2. b)

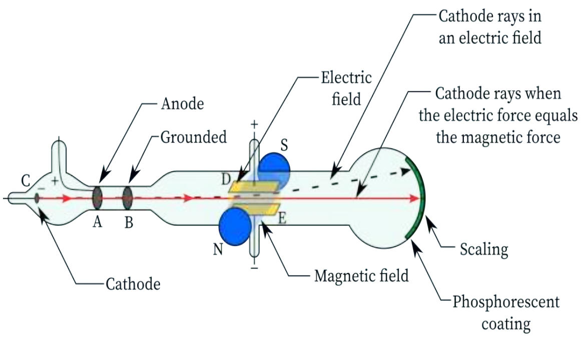
3. b)

4. b)

5. b)

CROSS FIELDS : DISCOVERY OF THE ELECTRON

Both an electric field E and a magnetic field B can produce a force on a charged particle. When the two fields are perpendicular to each other, they are said to be cross-fields. The figure shows a simplified version of Thomson's experimental apparatus-a cathode ray tube. The charged particles (electrons) are emitted by cathode ray tube headed toward screen, where they produce a spot of light. Thomson could control the spot by adjusting E and B. When the two fields are adjusted so that two deflecting forces cancel. $qE = qvB \sin 90° \rightarrow E = vB$



$v = \frac{E}{B}$; If the forces are cancelling each other then there will be no deflection shown by the particle.

1. An electron that has instantaneous velocity of $\vec{V} = (-5x10^6 m/s)\hat{i} + (3x10^6\ m/s)\hat{j}$ is moving through uniform magnetic field $\vec{B} = (0.03T)\hat{i} - (0.15T)\hat{j}$ the force on electron due to magnetic field is

a) $(-1.1x10^{-13} N)\hat{k}$
b) $(-1.1x10^{-13} N)\hat{k}$
c) $(-1.1x10^{-6} N)\hat{k}$
d) $(-1.1x10^{-6} N)\hat{k}$

2. An x-particle crosses a space without deflection. If $E=8x10^6 v/m$ and B=1.6T, the velocity of particle is

   a) $2.5x10^6$ m/s

   b) $5x10^6$ m/s

   c) $8x10^6$ m/s

   d) $5x10^7$ m/s

3. A beam of cathode rays is subjected to cross electric (E) and magnetic fields (B). The fields are adjusted such that the beam is not deflected. The specif charge (q/m) of the cathode rays is given by

   a) $\frac{B^2}{2VE^2}$ b) $\frac{2VB^2}{E^2}$ c) $\frac{2VE^2}{2B^2}$ d) $\frac{E^2}{2VB^2}$

4. A magnetic force does not change the __________ of the charged particle.

   a) Velocity

   b) Momentum

   c) Kinetic Energy

   d) All of the above

5. Cathode rays enter a magnetic field making oblique angle with the lines of magnetic induction. What will be the nature of the path followed?

   a) Parabola

   b) Helix

   c) Circle

   d) Straight line

Answers

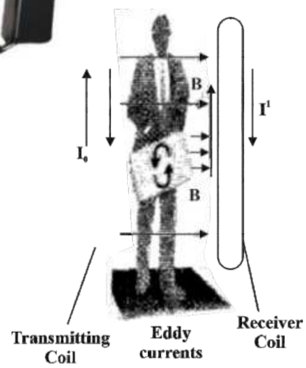
1. a)
2. b)
3. d)
4. c)
5. b)

(UNIT : IV)

Case Study

III. Metal Detector :

The operation of metal detectors is based on the principle of Electro Magnetic Induction (EMI). Metal detectors contain one or more inductor coils that are used to interact with metallic elements on the ground. A pulsating current is to the coil which then induces a magnetic fields. When the magnetic field of the coil moves across metal, the field increase the induction of magnetic field. This results to induction of electric currents known as Eddy currents. The eddy currents induce their own magnetic field, which generates an opposite current in the coil, which induces a signal indicating the presence of metal.



1. Which of the following will not increase the size and effect of eddy currents?
   a) Low resistivity materials
   b) Strong Magnetic Field
   c) Thicker material
   d) Thinner material
2. In electromagnetic induction, line integral of induced field E around a closed path is _________, induced electric field is ________.
   a) Zero, Non-conservative b) Non Zero, Conservative
   c) Zero, conservative d) Non zero, Non conservative

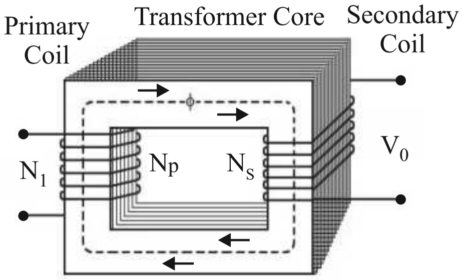
3. Eddy currents do not cause ___________.
   a) Sparking
   b) heating
   c) Loss of energy
   d) Damping
4. The magnetic flux through a circuit of resistance R changes by an amount in time it. Then the total charge q that passes during this time through any point of the circuit is
   a) $q = \frac{\Delta\phi}{\Delta t}$ b) $q = \frac{\Delta\phi}{\Delta t} R$
   c) $q = \frac{\Delta\phi}{\Delta t} R$ d) $q = \frac{\Delta\phi}{R}$
5. A hollow metallic cylinder is held vertically. A small bar magnet dropped along its axis will fall with acceleration such that.
   a) $a > g$ b) $a < g$ c) a=g d) a=o

Answers

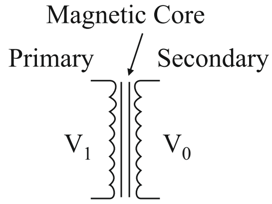
1. d)
2. d)
3. a)
4. d)
5. b)

IV. Transformers

Transformers are most commonly used for increasing low AC voltages at high current (Step-up transformers) or decreasing high AC voltage at low current (Step-down) in electric power applications. It works on mutual induction. An ideal transformer is a theoretical linear transformer that has no loss and perfectly coupled. But a real transformer has some losses like core loss, eddy current, heat loss, flux leakage etc. The emf of a transformer at a given flux increase with frequency by operating at higher frequencies, the transformers can be physically more compact. Aircraft and Military equipments employ 400 Hz power supplies which reduces the weight of core and winding.



Transformer Construction



Transformer Symbols

1. High voltage transmission line is preferred because
   a) Its appliances are less costly.
   b) Thin power cables are required.
   c) Idle current is small
   d) Power loss is less.
2. To manufacture the core of a transformer, the best material is
   a) Stainless steel
   b) Hard steel
   c) Soft iron
   d) Mild steel
3. A step-up transformer is used to convert 20V, 10 A a.c with frequency 50Hz to 200V, 1 A a.c. The frequency of output a.c will be
   a) 5 Hz b) 500 Hz c) 0.5 Hz d) 50 Hz

4. In an inducting furnace (used for melting metals) which type of transformer is used

   a) Step-up   b) Step-down

   c) Any one of them   d) No need of transformation

5. A step-down transformer is used to reduce the main supply of 220 V to 11 V. If the primary draws a current of 5A and the secondary 90A efficiency of transformer is

   a) 95%   b) 90%

   c) 9%   d) 45%

Answers

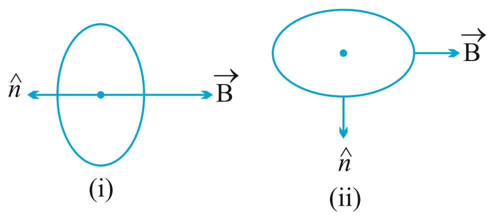
1. d)   2. c)   3. d)   4. b)   5. b)

SHORT ANSWERS QUESTIONS (2 MARKS)

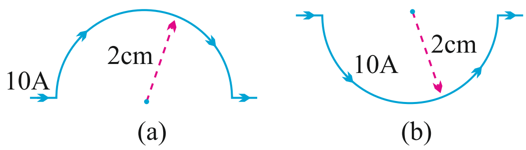
1. Write the four measures that can be taken to increase the sensitivity of galvanometer.

2. A galvanometer of resistance 120Ω gives full scale deflection for a current of 5mA. How can it be converted into an ammeter of range 0 to 5A? Also determine the net resistance of the ammeter.

3. A current loop is placed in a uniform magnetic field in the following orientations (i) and (ii). Calculate the magnetic moment in each case.



4. A current of 10A flows through a semicircular wire of radius 2 cm as shown in figure (a). What is direction and magnitude of the magnetic field at the centre of semicircle? Would your answer change if the wire were bent as shown in figure (b) ?



5. A proton and an alpha particle of the same speed enter, in turn, a region of uniform magnetic field acting perpendicular speed to their direction of motion. Deduce the ratio of the radii of the circular paths described by the proton and alpha particle.

6. Why does the susceptibility of dimagnetic substance independent of temperature ?

Ans. As there is no permanent dipoles in dimagnetic substance, so, there is no meaning of randomness of dipoles on increasing temp.

7. Mention two properties of soft iron due to which it is preferred for making electromagnet.

Ans. Low retentivity, low coercivity

8. A magnetic dipole of magnetic moment M is kept in a magnetic field B. What is the minimum and maximum potential energy? Also give the most stable position and most unstable position of magnetic dipole.

9. What will be (i) Pole strength, (ii) Magnetic moment of each of new piece of bar magnet if the magnet is cut into two equal pieces :

(a) normal to its length?

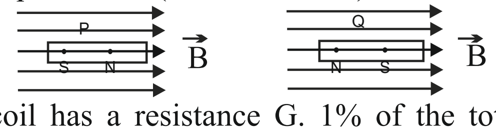
(b) along its length?

10. A steady current I flows along an infinitely long straight wire with circular cross-section of radius R. What will be the magnetic field outside and inside the wire at a point r distance far from the axis of wire?

11. A circular coil of n turns and radius R carries a current I. It is unwound and rewound to make another square coil of side 'a' keeping number of turns and current same. Calculate the ratio of magnetic moment of the new coil and the original coil.

12. A coil of N turns and radius R carries a current I. It is unwound and rewound to make another coil of radius R/2, current remaining the same. Calculate the ratio of the magnetic moment of the new coil and original coil.

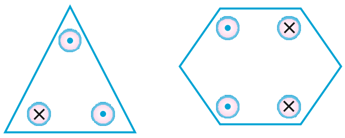
13. Two identical bar magnets P and Q are placed in two identical uniform magnetic fields as shown. Justify that both the magnets are in equilibrium. Identify the type of equilibrium. (stable/unstable)



14. A galvanometer coil has a resistance G. 1% of the total current goes through the coil and rest through the shunt. What is the resistance of the shunt in terms of G?

15. Prove that magnetic moment of a hydrogen atom in its ground state is $eh/4\pi m$. Symbols have their usual meaning.

16. Each of conductors shown in figure carries 2A of current into or out of page. Two paths are indicated for the line integral $\oint \vec{B}.d\vec{l}$. What is the value of the integral for the path (a) and (b).



(a) (b)

17. What is the radius of the path of an electron (mass 9×10^{-31} kg and charge 1.6×10^{-19} C) moving at a speed of 3×10^7 m/s in a magnetic field of 6×10^{-4} T perpendicular to it? What is its frequency? Calculate its energy in keV. (1 eV = 1.6×10^{-19} J).

Ans. Radius, $r = mv/(qB)$

$= 9.1 \times 10^{-31}$ kg $\times 3 \times 10^7$ ms^{-1}/(1.6×10^{-19} C $\times 6 \times 10^{-4}$ T) = 20 cm

$\nu = v/(2\pi r) = 1.7 \times 10^7$ Hz

$E = (1/2)mv^2 = (1/2)\ 9 \times 10^{-31}$ kg $\times 9 \times 10^{14}$ m^2/s^2

$= 40.5 \times 10^{-17}$ J $= 4 \times 10^{-16}$ J = 2.5 keV.

18. Why is it necessary for voltmeter to have a higher resistance?

Ans. Since voltmeter is to be connected across two points in parallel, if it has low resistance, a part of current will pass through it which will decrease actual potential difference to be measured.

19. Can d.c. ammeter use for measurement of alternating current?

Ans. No, it is based on the principle of torque. When ac is passing through it (of freq. 50 Hz). It will not respond to frequent change in direction due to inertia hence would show zero deflection.

20. Define the term magnetic dipole moment of a current loop. Write the expression for the magnetic moment when an electron revolves at a speed 'v', around an orbit of radius 'r' in hydrogen atom.

Ans. The product of the current in the loop to the area of the loop is the magnetic dipole moment of a current loop.

The magnetic moment of electron

$$\bar{\mu} = -\frac{e}{2}\left(\vec{r} \times \vec{v}\right) = -\frac{e}{2m_e}\left(\vec{r} \times \vec{p}\right) = -\frac{e}{2m_e}\vec{\ell}$$

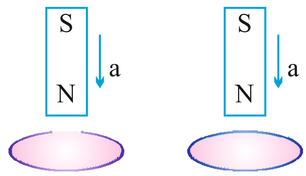
21. An ac source of rms voltage V is put across a series combination of an inductor L, capacitor C and a resistor R. If V_L, V_C and V_R are the rms voltage across L, C and R respectively then why is $V \neq V_L + V_C + V_R$? Write correct relation among V_L, V_C and V_R.

Ans. Hint :

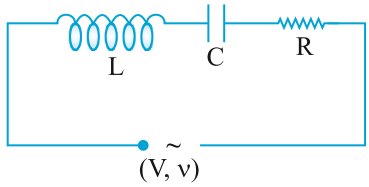
V_L, V_C and V_R are not in the same phase

$V_L + V_C + V_R > V$

22. A bar magnet is falling with some acceleration 'a' along the vertical axis of a coil as shown in fig. What will be the acceleration of the magnet (whether $a > g$ or $a < g$ or $a = g$) if (a) coil ends are not connected to each other? (b) coil ends are connected to each other?



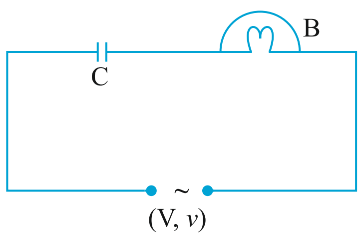
23. The series L–C–R circuit shown in fig. is in resonance state. What is the voltage across the inductor?



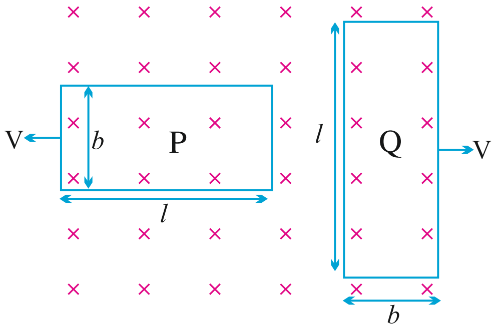
Ans. [Hint $V_L = I\,X_L$ where $I = \dfrac{V}{R}$]

24. The division marked on the scale of an a.c. ammeter are not equally spaced. Why?

25. Circuit shown here uses an air filled parallel plate capacitor. A mica sheet is now introduced between the plates of capacitor. Explain with reason the effect on brightness of the bulb B.



26. In the figure shown, coils P and Q are identical and moving apart with same velocity V. Induced currents in the coils are I_1 and I_2. Find I_1/I_2.



27. An electron moving through magnetic field does not experience mgnetic force, under what conditions is this possible ?

Ans. when electron moving parallel to magnetic field.

28. A 1.5 μF capacitor is charged to 57V. The charging battery is then disconnected, and a 12 mH coil is connected in series with the capacitor so that LC Oscillations occur. What is the maximum current in the coil? Assume that the circuit has no resistance.

29. The self inductance of the motor of an electric fan is 10H. What should be the capacitance of the capacitor to which it should be connected in order to impart maximum power at 50Hz?

30. A galvanometer needs 50mV for full scale deflection of 50 Divisions. Find it voltage sensitivity. What must be its resistance if its current sensitivity is 1 Div/A.

Ans. $V_s = \frac{\theta}{V} = \frac{50\text{Div}}{50\text{mv}} = 10^3 \text{ div}/\ v$ $\qquad I_s \rightarrow$ Current sensitivity

$R_g = \frac{I_S}{V_S} = 10^{-3}\text{w}$ $\qquad V_S \rightarrow$ Voltage sensitivity

31. How does an inductor behave in an AC circuit at very high frequency? Justify.

32. An electric bulb is connected in series with an inductor and an AC source. When switch is closed. After sometime an iron rod is inserted into the interior of inductor. How will the brightness of bulb be affected? Justify your answer.

Ans. Decreases, due to increase in inductive reactance.

33. Show that in the free oscillation of an LC circuit, the sum of energies stored in the capacitor and the inductor is constant with time.

Ans. Hint : $U = \frac{1}{2}LI^2 + \frac{1}{2}\frac{q^2}{c}$

34. Show that the potential difference across the LC combination is zero at the resonating frequency in series LCR circuit

Ans. Hint : P.d. across L is $= IX_L$

P.D. across C is $= IX_C$

$\Rightarrow \quad V = IX_L - IX_C$

at resonance $X_L = X_C$

$\Rightarrow \quad V = O.$

34. When a large amount of current is passing through solenoid, it contract, explain why ?

Ans. Current in two consecutive turns being in same direction make them to form unlike poles together hence, they attract each other.

35. for circuits used for transmitting electric power, a low power factor implies large power loss in transmission. Explain.

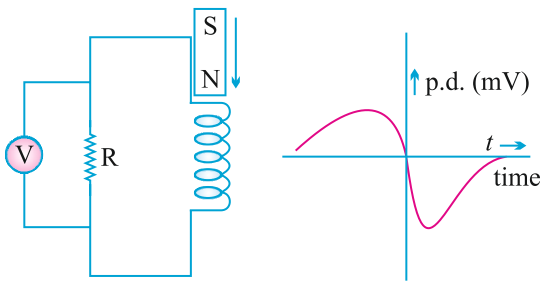
$\therefore \quad P = VI\cos\theta$

$$I = \frac{P}{V\cos\theta}$$

If $\cos\phi$ is low I will be high $\Rightarrow$ Large power loss.

36. An applied voltage signal consists of a superposition of DC Voltage and an AC Voltage of high frequency. The circuit consists of an inductor and a capacitor in series. Show that the DC signal will appear across C where as AC signal will appear across L.

37. A bar magnet M is dropped so that is falls vertically through the coil C. The graph obtained for voltage produced across the coil Vs time is shown in figure.



(i) Explain the shape of the graph.

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

Ans. (i) When the bar magnet moves towards the coil magnetic flux passing through the coil increases as velocity of magnet increases in downward direction, e.m.f. induced also increases, due to formation of similar pole repulsive force decreases the rate of increase of flux.

(ii) once the magnet has passed through the coil, flux decreases in downward direction but $\frac{d\phi}{dt}$ increases as self induced e.m.f. in the coil maintains its flux in the same direction. Thus due to the addition of self induced e.m.f. in same direction according to Lenz's law.

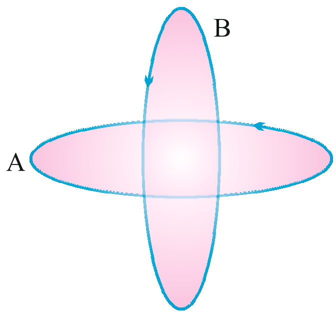
38. What is the significance of Q-factor in a series LCR resonant circuit ?

39. How does mutual inductance of a pair of coils kept coaxially at a distance in air change when

(i) the distance between the coils is increased?

(ii) an iron rod is kept between them?

40. Two circular conductors are perpendicular to each other as shown in figure. If the current is changed in conductor B, will a current be induced in the conductor A,



41. What is a radial magnetic field? Why is it required in a galvanometer ?

Ans. Using concave shaped pole of magnet and placing soft iron cylinderical core, A magnetic field, having field lines along radii is called as radial magnetic field.

To make Torque independent of 'θ' (constant) radial magnetic field is required $\tau = NIAB \sin \theta$

for radial Magnetic Field $\theta = 90°$

$\tau = NIAB$. (independent of θ)

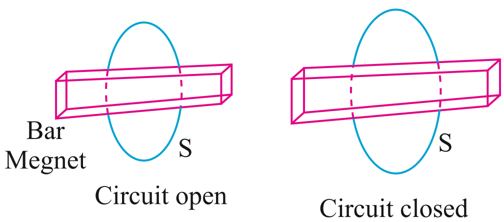
42. A wire in the form of a tightly wound Solenoid is connected to a DC source, and carries a current. If the coil is stretched so that there are gaps between successive elements of the spiral coil, will the current increase or decrease ? Explain ?

Ans. When the coil is stretched so that there are gaps between successive elements of the spiral coil *i.e.* the wires are pulled apart which lead to the flux leak through the gaps. According to Lenz's law, the e.m.f. produced must oppose this decrease, which can be done by an increase in current. So, the current will increase.

43. Show that the induced charge does not depend upon rate of change of flux.

Ans.
$$|E| = N\frac{d\phi}{dt}$$
$$i = \frac{E}{R} = \frac{N}{R}\frac{d\phi}{dt}$$
$$\frac{dq}{dt} = \frac{N}{R}\frac{d\phi}{dt}$$
$$\therefore \quad dq = \frac{N}{R}d\phi$$

44. 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.



Ans. $\phi = BA\cos\theta$ so flux linked will change only when either B or A or the angle between B and A change.

When switch is thrown from off position to the on position, then neither B nor A nor the angle between A and B change. Thus there is no change in magnetic flux linked with the coil, hence no electromotive force (e.m.f.) is produced and consequently no current will flow in the circuit.

Short answers Questions (3 marks)

1. Derive the expression for force between two infinitely long parallel straight wires carrying current in the same direction. Hence define 'ampere' on the basis of above derivation.

2. Derive formula of mutual inductance of coaxial solenoids.

3. Distinguish between diamagnetic, paramagnetic and ferromagnetic substances in terms of susceptibility and relative permeability.

4. Name all the three elements of earth magnetic field and define them with the help of relevant diagram.

5. Describe the path of a charged particle moving in a uniform magnetic field with initial velocity
   (i) parallel to (or along) the field.
   (ii) perpendicular to the field.
   (iii) at an arbitrary angle θ ($0^o < \theta < 90^o$).

6. Obtain an expression for the magnetic moment of an electron moving with a speed 'v' in a circular orbit of radius 'r'. How does the magnetic moment change when :
   (i) the frequency of revolution is doubled?
   (ii) the orbital radius is halved?

7. State Ampere, circuital law. Use the law to obtain an expression for the magnetic field due to a toroid.

8. Obtain an expression for magnetic field due to a long solenoid at a point inside the solenoid and on the axis of solenoid.

9. Derive an expression for the torque on a magnetic dipole placed in a magnetic field and hence define magnetic moment.

10. Derive an expression for magnetic field intensity due to a bar magnet (magnetic dipole) at any point (i) Along its axis (ii) Perpendicular to the axis.

11. Derive an expression for the torque acting on a loop of N turns of area A of each turn carrying current I, when held in a uniform magnetic field B.

12. How can a moving coil galvanometer be converted into a voltmeter of a given range. Write the necessary mathematical steps to obtain the value of resistance required for this purpose.

13. A long wire is first bent into a circular coil of one turn and then into a circular coil of smaller radius having n turns. If the same current passes in both the cases, find the ratio of the magnetic fields produced at the centres in the two cases.

Ans. When there is only one turn, the magnetic field at the centre,

$$B = \frac{\mu_0 I}{2a}$$

$$2\pi a' \times n = 2\pi a \Rightarrow a' = a/n$$

The magnetic field at its centre, $B_1 = \frac{\mu_0 n I}{2a/n} = \frac{\mu_0 n^2 I}{2a} = n^2 B$

The ratio is, $B_1/B = n^2$

14. Obtain an expression for the self inductance of a straight solenoid of length l and radius r ($l >> r$).

15. Distinguish between : (i) resistance and reactance (ii) reactance and impedance.

16. In a series L–C–R circuit X_L, X_C and R are the inductive reactance, capacitive reactance and resistance respectively at a certain frequency f. If the frequency of a.c. is doubled, what will be the values of reactances and resistance of the circuit?

Ans. [Hint : $X_L = \omega L$, $X_C = \frac{1}{\omega C}$, R independent]

17. What are eddy currents? Write their any four applications.

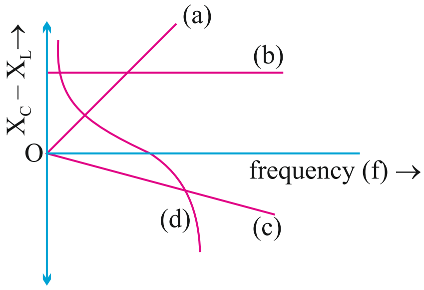
18. In a series L–R circuit, $X_L = R$ and power factor of the circuit is P_1. When capacitor with capacitance C such that $X_L = X_C$ is put in series, the power factor becomes P_2. Find P_1/P_2.

Ans. [Hint $P = \cos\theta = \frac{R}{Z}$]

19. Instantaneous value of a.c. voltage through an inductor of inductance L is $e = e_0 \cos \omega t$. Obtain an expression for instantaneous current through the inductor. Also draw the phasor diagram.

20. In an inductor of inductance L, current passing is I_0. Derive an expression for energy stored in it. In what forms is this energy stored?

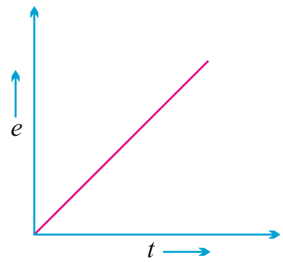
21. Which of the following curves may represent the reactance of a series LC combination.



22. A sinusoidal e.m.f. device operates at amplitude E_0 and frequency ν across a purely (1) resistive (2) capacitive (3) inductive circuit. If the frequency of driving source is increased. How would (a) amplitude E_0 and (b) amplitude I_0 increase, decrease or remain same in each case?

23. A conducting rod held horizontally along East-West direction is dropped from rest at certain height near Earth's surface. Why should there be an induced e.m.f. across the ends of the rod? Draw a graph showing the variation of e.m.f. as a function of time from the instant it begins to fall.

Ans. Hint : $e = Blv$ and $v = gt$



24. In an LC circuit, resistance of the circuit is negligible. If time period of oscillation is T then :

(i) at what time is the energy stored completely electrical

(ii) at what time is the energy stored completely magnetic

(iii) at what time is the total energy shared equally between the inductor and capacitor.

Ans. (i) $t = 0, T/2, 3T/2, \ldots\ldots\ldots$

(ii) $t = T/4, 3T/4, 5T/4 \ldots\ldots\ldots\ldots$

(iii) $t = \frac{T}{8}, \frac{3T}{8}, \frac{5T}{8}, \ldots\ldots\ldots$

25. An alternating voltage of frequency f is applied across a series LCR circuit. Let f_r be the resonance frequency for the circuit. Will the current in the circuit lag, lead or remain in phase with the applied voltage when (i) $f > f_r$ (ii) $f < f_r$ (iii) $f = f_r$? Explain your answer in each case.

Ans. (i) Current will lag because.

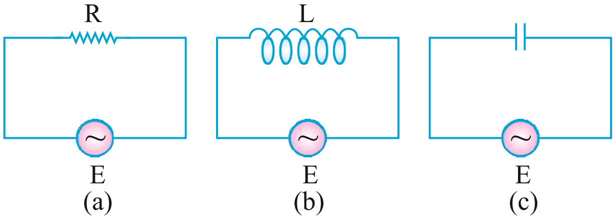
$V_L > V_C$ Hence $V_L - V_C > O$

(ii) Current will lead, because.

$V_L < V_C$ Hence $V_L - V_C < O$

(iii) In phase

26. Figure (a), (b), (c) show three alternating circuits with equal currents. If the frequency of alternating emf be increased, what will be the effect on current in the three cases? Explain.

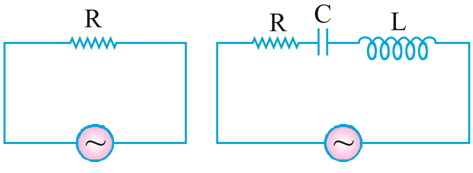


Ans. (i) No effect, R is not affected by frequency.

(ii) Current will decrease as X_L increase.

(iii) Current will increase as X_C decrease.

27. Study the circuit (a) and (b) shown in the figure and answer the following questions.



(a) Under which condition the rms current in the two circuits to be the same?

(b) Can the r.m.s. current in circuit (b) larger than that of in (a) ?

Ans. $I_{rms(a)} = \frac{V_{rms}}{R} = \frac{V}{R}$ $I_{rms(b)} = \frac{V_{rms}}{Z} = \frac{V}{\sqrt{R^2 + (X_L - X_C)^2}}$

(a) $I_{rms(a)} = I_{rms(b)}$

when $X_L = X_c$ (resonance condition)

$$\frac{I_{rms(a)}}{I_{rms(b)}} = \frac{Z}{R} = 1$$

(b) As $z \geq R$

$$I_{rms(a)} \geq I_{rms(b)}$$

No, the rms current in circuit (b), cannot be larger than that in (a).

28. Can the instantaneous power output of an AC source ever be negative ? Can average power output be negative ? Justify your answer.

Ans. Yes, Instantaneous power output of an AC source can be negative.

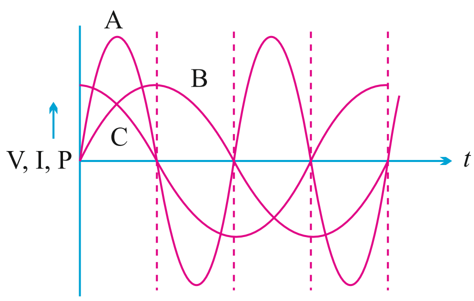
Instantaneous power output $P = EI = \frac{E.I.}{2}[\cos\phi - \cos(2\omega t + \phi)]$

No, $P_{avc} = V_{rms}\, I_{rms} \cos\phi$

$P_{avc} > 0$

$\cos\phi = \frac{R}{Z} > 0$

29. A device 'X' is connected to an AC source. The variation of voltage, current and power in one complete cycle is shown in fig.



(a) Which curves shows power consumption over a full cycle?

(b) What is the average power consumption over a cycle?

(c) Identify the device X if curve B shows voltage.

Ans. (a) A (a curve of power have a max. Amplitude of V and I)

(b) Zero.

(c) as current leads voltage the device is a capacitor.

SECTION - E

LONG ANSWER QUESTIONS (5 MARKS)

1. How will a diamagnetic, paramagnetic and a ferromagnetic material behave when kept in a non-uniform external magnetic field? Give two examples of each of these materials. Name two main characteristics of a ferromagnetic material which help us to decide suitability for making.
(i) Permanent magnet (ii) Electromagnet.

2. State Biot-Savart law. Use it to obtain the magnetic field at an axial point, distance d from the centre of a circular coil of radius 'a' and carrying current I. Also compare the magnitudes of the magnetic field of this coil at its centre and at an axial point for which the value of d is $\sqrt{3a}$.

3. A. Straight thick long wire of uniform cross section of radius 'a' is carrying a steady current I. Use ampere's circuital law to obtain a relation showing the variation of magnetic field (Br) inside and outside the wire with distance r ($r \leqslant a$) and ($r > a$) of the field point from centre of its cross section. Plot a graph showing variation of field (B) with distance r.

***4.** Write the principle, working of a moving coil galvanometer with the help of neat labelled diagram. What is the importance of radial field and phosphor bronze used in the construction of moving coil galvanometer?

5. Draw a labelled diagram to explain the principle and working of an a.c. generator. Deduce the expression for emf generated. Why cannot the current produced by an a.c. generator be measured with a moving coil ammeter?

6. Explain, with the help of a neat and labelled diagram, the principle, construction and working of a transformer.

7. An L–C circuit contains inductor of inductance L and capacitor of capacitance C with an initial charge q_0. The resistance of the circuit is negligible. Let the instant the circuit is closed be $t = 0$.

(i) What is the total energy stored initially?

(ii) What is the maximum current through inductor?

(iii) What is the frequency at which charge on the capacitor will oscillate?

(iv) If a resistor is inserted in the circuit, how much energy is eventually dissipated as heat?

8. An a.c. $i = i_0 \sin \omega t$ is passed through a series combination of an inductor (L), a capacitor (C) and a resistor (R). Use the phasor diagram to obtain expressions for the (a) impedance of the circuit and phase angle between voltage across the combination and current passed in it. Hence show that the current

   (i) leads the voltage when $\omega < \dfrac{1}{\sqrt{LC}}$

   (ii) is in phase with voltage when $\omega = \dfrac{1}{\sqrt{LC}}$.

9. Write two differences in each of resistance, reactance and impedance for an ac circuit. Derive an expression for power dissipated in series LCR circuit.

NUMERICALS

1. An electron travels on a circular path of radius 10 cm in a magnetic field of 2×10^{-3} T. Calculate the speed of electron. What is the potential difference through which it must be accelerated to acquire this speed?
   [Ans. Speed = 3.56×10^{7} m/s; V = 3.56×10^{7} volts**]**
2. A charge particle of mass m and charge q entered into magnetic field B normally after accelerating by potential difference V. Calculate radius of its circular path. **[Ans.** $r = \dfrac{1}{B}\sqrt{\dfrac{2mv}{q}}$ **]**
3. Calculate the magnetic field due to a circular coil of 500 turns and of mean diameter 0.1m, carrying a current of 14A (i) at a point on the axis distance 0.12 m from the centre of the coil (ii) at the centre of the coil.
   [Ans. (i) 5.0×10^{-3} tesla; (ii) 8.8×10^{-2} tesla**]**
4. An electron of kinetic energy 10 keV moves perpendicular to the direction of a uniform magnetic field of 0.8 milli tesla. Calculate the time period of rotation of the electron in the magnetic field.
   [Ans. 4.467×10^{-8} s.**]**
5. If the current sensitivity of a moving coil galvanometer is increased by 20% and its resistance also increased by 50% then how will the voltage sensitivity of the galvanometer be affected? **[Ans.** 25% decrease**]**

6. A uniform wire is bent into one turn circular loop and same wire is again bent in two circular loop. For the same current passed in both the cases compare the magnetic field induction at their centres.

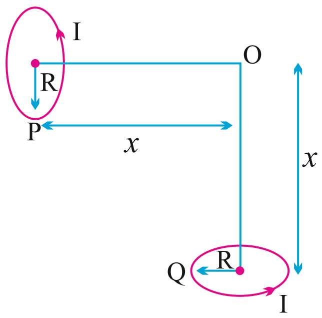
[Ans. Increased 4 times**]**

7. A horizontal electrical power line carries a current of 90A from east to west direction. What is the magnitude and direction of magnetic field produced by the power line at a point 1.5 m below it?

[Ans. 1.2×10^{-5} T South ward**]**

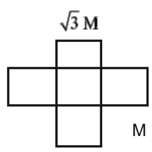
8. A galvanometer with a coil of resistance 90Ω shows full scale deflection for a potential difference 25mV. What should be the value of resistance to convert the galvanometer into a voltmeter of range 0V to 5V. How should it be converted? **[Ans.** 1910 Ω in series]

9. Two identical circular loops P and Q carrying equal currents are placed such that their geometrical axis are perpendicular to each other as shown in figure. And the direction of current appear's anticlockwise as seen from point O which is equidistant from loop P and Q. Find the magnitude and direction of the net magnetic field produced at the point O.



$\tan\theta = \frac{B_2}{B_1} = 1,\ \theta = \pi/4.$ **[Ans.** $\frac{\mu_0 I R^2 \sqrt{2}}{2(R^2 + x^2)^{3/2}}$]

10. Two magnets of magnetic moments M and $\sqrt{3}$ M are joined to form a cross The combination is suspended in uniform magnetic field B. the magnetic moment M now makes an angle 'θ' with field direction . find the value of θ.



(Ans: $\theta = 60^0$)

11. The coil of a galvanometer is 0.02 × 0.08 m^2. It consists of 200 turns of fine wire and is in a magnetic field of 0.2 tesla. The restoring torque constant of the suspension fibre is 10^{-6} Nm per degree. Assuming the magnetic field to be radial.

(i) What is the maximum current that can be measured by the galvanometer, if the scale can accommodate 30° deflection?

(ii) What is the smallest, current that can be detected if the minimum observable deflection is 0.1°?

[Ans. (i) 4.69×10^{-4} A; (ii) 1.56×10^{-6} A**]**

12. A voltmeter reads 5V at full scale deflection and is graded according to its resistance per volt at full scale deflection as $5000\Omega V^{-1}$. How will you convert it into a voltmeter that reads 20V at full scale deflection? Will it still be graded as $5000\ \Omega V^{-1}$? Will you prefer this voltmeter to one that is graded as $2000\ \Omega V^{-1}$? **[Ans.** $7.5 \times 10^4\ \Omega$**]**

13. A short bar magnet placed with its axis at 30° with an external field 1000G experiences a torque of 0.02 Nm. (i) What is the magnetic moment of the magnet. (ii) What is the work done in turning it from its most stable equilibrium to most unstable equilibrium position?

[Ans. (i) 0.4 Am^2; (ii) 0.08 J]

14. What is the magnitude of the equatorial and axial fields due to a bar magnet of length 4 cm at a distance of 40 cm from its mid point? The magnetic moment of the bar magnet is a 0.5Am^2.

[Ans. $B_E = 7.8125 \times 10^{-7}$ T; $B_A = 15.625 \times 10^{-7}$ T**]**

15. What is the magnitude of magnetic force per unit length on a wire carrying a current of 8A and making an angle of 30° with the direction of a uniform magnetic field of 0.15T?

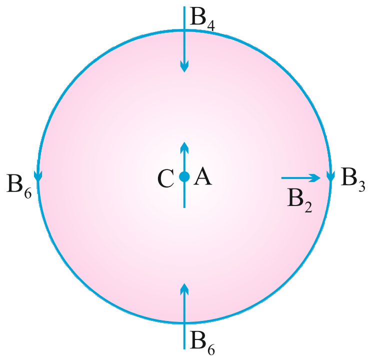
16. Two moving coil galvanometers, M_1 and M_2 have the following specifications.

$R_1 = 10\Omega$, $N_1 = 30$, $A_1 = 3.6 \times 10^{-3} m^2$, $B_1 = 0.25T$

$R_2 = 14\Omega$, $N_2 = 42$, $A_2 = 1.8 \times 10^{-3} m^2$, $B_2 = 0.50T$

Given that the spring constants are the same for the two galvanometers, determine the ratio of (a) current sensitivity (b) voltage sensitivity of M_1 & M_2. **[Ans.** (a) 5/7 (b) 1:1**]**

17. In the given diagram, a small magnetised needle is placed at a point O. The arrow shows the direction of its magnetic moment. The other arrows shown different positions and orientations of the magnetic moment of another identical magnetic needs B.



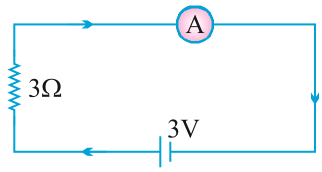
(a) In which configuration is the systems not in equilibrium?

(b) In which configuration is the system.

(i) stable and (ii) unstable equilibrium?

(c) Which configuration corresponds to the lowest potential energy among all the configurations shown?

18. In the circuit, the current is to be measured. What is the value of the current if the ammeter shown :

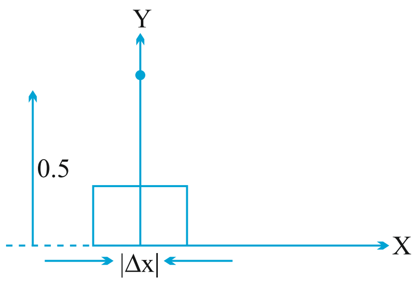


(a) is a galvanometer with a resistance $R_G = 60\ \Omega$,

(b) is a galvanometer described in (i) but converted to an ammeter by a shunt resistance $r_s = 0.02\Omega$

(c) is an ideal ammeter with zero resistance?

19. An element $\Delta I = \Delta x \cdot \hat{i}$ is placed at the origin and carries a large current I = 10A. What is the magnetic field on the y-axis at a distance of 0.5 m. Δx = 1 cm.



20. A straight wire of mass 200 g and length 1.5 m carries a current of 2A. It is suspended in mid-air by a uniform horizontal magnetic field B. What is the magnitude of the magnetic field?

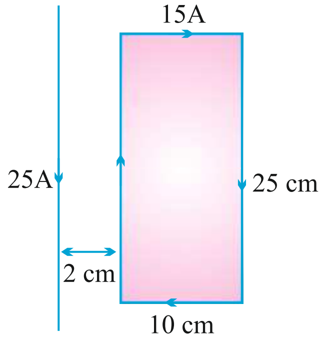
21. A rectangular loop of sides 25 cm and 10 cm carrying current of 15A is placed with its longer side parallel to a long straight conductor 2.0 cm apart carrying a current of 25A. What is the new force on the loop ? **[Ans.** 7.82×10^{-4} N towards the conductor**]**

Hint :

$$F_1 = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{r_1}\times \ell = \frac{10^{-7}\times 2\times 25\times 15\times 0.25}{0.02} = 9{\cdot}38 \times 10^{-4} \text{ N attractive}$$

$$F_2 = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{r_2}\times \ell = \frac{10^{-7}\times 2\times 25\times 15\times 0.25}{0.12} = 1.56 \times 10^{-4} \text{ N repulsive}$$

Net $F = F_1 - F_2 = 7.82 \times 10^{-4}$ N



22. In a chamber of a uniform magnetic field 6.5G is maintained. An electron is shot into the field with a speed of 4.8×10^6 ms^{-1} normal to the field. Explain why the path of electron is a circle.

(a) Determine the radius of the circular orbit ($e = 1.6 \times 10^{-19}$ C, $m_e = 9.1 \times 10^{-31}$ kg)

(b) Obtain the frequency of resolution of the electron in its circular orbit.

Hint : (a) $r = \dfrac{m_e v}{eB} = \dfrac{9.1\times 10^{-31}\times 4.8\times 10^{6}}{1.6\times 10^{-19}\times 6.5\times 10^{-4}} = 4.2$ cm

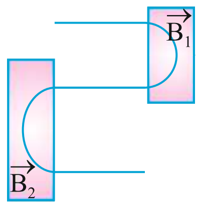
(b) frequency $v = \dfrac{1}{T} = \dfrac{eB}{2\pi m_e} = \dfrac{1.6\times 10^{-19}\times 6.5\times 10^{-4}}{2\times 3.14\times 9.1\times 10^{-31}} = 18$ MHz

23. A muon is a partical that has same charge as on electron but 200 times heavier than it. If we had an atom in which muon revolves around proton instead of electron, what would be the magnetic moment the muon in ground state of such atom ?

Ans: $4.63\text{X}10^{-26}$ Am^2

24. Figure shows the path of an electron that passes through two regions containing uniform magnetic fields of magnitude B_1 and B_2. Its path in each region is a half circle. (a) which field is stronger? (b) What are the directions of two fields? (c) Is the time spend by the electron in the $\vec{B}_1$, region greater than, less than, or the same as the time spent in $\vec{B}_2$ region?

[Ans. (a) $B_1 > B_2$; (b) B_1 inward; B_2 outward (c) Time spent in B_1 < Time spent in B_2]



25. In a series C–R circuit, applied voltage is $V = 110 \sin 314t$ volt. What is the (i) The peak voltage (ii) Average voltage over half cycle ?

26. Magnetic flux linked with each turn of a 25 turns coil is 6 milliweber. The flux is reduced to 1 mWb in 0.5s. Find induced emf in the coil.

27. The current through an inductive circuit of inductance 4mH is $i = 12 \cos 300t$ ampere. Calculate :

(i) Reactance of the circuit.

(ii) Peak voltage across the inductor.

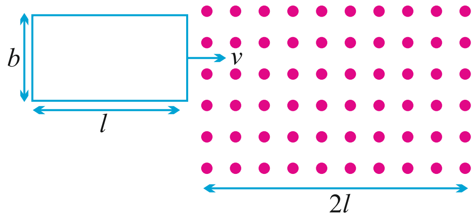
28. A power transmission line feeds input power at 2400 V to a step down ideal transformer having 4000 turns in its primary. What should be number of turns in its secondary to get power output at 240V?

29. The magnetic flux linked with a closed circuit of resistance 8Ω varies with time according to the expression $\phi = (5t^2 - 4t + 2)$ where ϕ is in milliweber and t in second. Calculate the value of induce current at $t = 15\ s$.

30. A capacitor, a resistor and 4 henry inductor are connected in series to an a.c. source of 50 Hz. Calculate capacitance of capacitor if the current is in phase with voltage.

31. A series C–R circuit consists of a capacitance 16 mF and resistance 8Ω. If the input a.c. voltage is (200 V, 50 Hz), Calculate (i) voltage across capacitor and resistor. (ii) Phase by which voltage lags/leads current.

32. A rectangular conducting loop of length l and breadth b enters a uniform magnetic field B as shown below.



The loop is moving at constant speed v and at $t = 0$ it just enters the field B. Sketch the following graphs for the time interval $t = 0$ to $t = \frac{3l}{v}$.

(i) Magnetic flux versus time
(ii) Induced emf versus times
(iii) Power versus time
Resistance of the loop is R.

33. A charged 8mF capacitor having charge 5mC is connected to a 5mH inductor. What is :

(i) the frequency of current oscillations?
(ii) the frequency of electrical energy oscillations in the capacitor?
(iii) the maximum current in the inductor?
(iv) the magnetic energy in the inductor at the instant when charge on capacitor is 4mC?

34. A 31.4Ω resistor and 0.1H inductor are connected in series to a 200V, 50Hz ac source. Calculate

(i) the current in the circuit
(ii) the voltage (rms) across the inductor and the resistor.
(iii) is the algebraic sum of voltages across inductor and resistor more than the source voltage ? If yes, resolve the paradox.

35. A square loop of side 12 cm with its sides parallel to X and Y-axis is moved with a velocity of 8 cm/s in positive x-direction. Magnetic field exists in *z*-directions.

(i) Determine the direction and magnitude of induced emf if the field changes with 10^{-3} Tesla/cm along negative *z*-direction.

(ii) Determine the direction and magnitude of induced emf if field changes with 10^{-3} Tesla/s along +*z* direction.

Ans. (i) Rate of change of flux = induced emf

$= (0.12)^2 \times 10^{-3} \times 8$

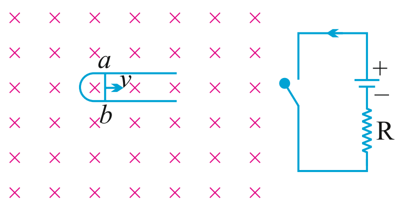
$= 11.52 \times 10^{-5}$ Wb/s in +*z* direction.

(ii) Rate of change of flux = induced emf

$= (0.12)^2 \times 10^{-3} \times 8$

$= 11.52 \times 10^{-5}$ Wb/s in –*z* direction.

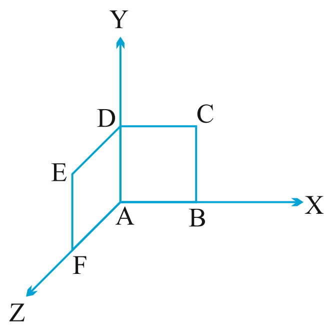
36. Figure shows a wire *ab* of length *l* which can slide on a U-shaped rail of negligible resistance. The resistance of the wire is R. The wire is pulled to the right with a constant speed *v*. Draw an equivalent circuit diagram representing the induced emf by a battery. Find the current in the wire.



$\varepsilon = Bvl$

$I = \varepsilon / r = \dfrac{Bvl}{R}$

37. A loop, made of straight edges has six corners at A(0, 0, 0), B(1, 0, 0), C(1, 1, 0), D(0, 1, 0), E(0, 1, 1) and F(0, 0, 1) a magnetic field $B = B_0\ (\hat{i} + \hat{k})$ T is present in the region. Find the flux passing through the loop ABCDEFA?



Ans. Loop ABCDA lie in x-y plane whose area vector $A_1 = L^2\hat{k}$ where ADEFA lie in y-z plane where are vector $A_2 = L^2\hat{i}$

ϕ = B.A, $\quad A = A_1 + A_2 = (L^2\hat{k} + L^2\hat{i})$

$B = B_0\ (\hat{i}+\hat{k})(L^2\hat{k}+L^2\hat{i}) = 2\ B_0L^2$ Wb.

38. A coil of 0.01 H inductance and 1Ω resistance is connected to 200V, 50 Hz AC supply. Find the impendence and time lag between maximum alternating voltage and current.

Ans. $$Z = \sqrt{R^2 + X_L^2} = \sqrt{R^2 + (2\pi f L)^2} = 3.3\Omega$$

$$\tan\phi = \frac{\omega L}{R} = \frac{2n f L}{R} = 3.14$$

$$\phi \cong 72^o$$

$$\text{Phase diff. } \phi = \frac{72\times\pi}{180}\text{rad.}$$

$$\omega = \frac{\Delta\phi}{\Delta t}, \text{ time lag } \Delta t = \frac{\phi}{\omega}$$

$$= \frac{72\pi}{180\times 2\pi\times 50} = \frac{1}{250}\ \text{s}$$

39. An electrical device draws 2 KW power from AC mains (Voltage = 223V, $V_{rms} = \sqrt{50000V}$). The current differ (lags) in phase by ϕ $\left(\tan\phi = \frac{-3}{4}\right)$ as compared to voltage. Find

(a) R

(b) $X_C - X_L$

(c) I_m

Ans. P = 2KW = 2000W ; $\tan\phi = \frac{-3}{4}$; $I_m = I_0$? R = ? $X_C - X_L$ = ?

$$V_{rms} = V = 223V$$

$$Z = \frac{V^2}{P} = 25\Omega$$

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

$$625 = R^2 + (X_L - X_C)^2$$

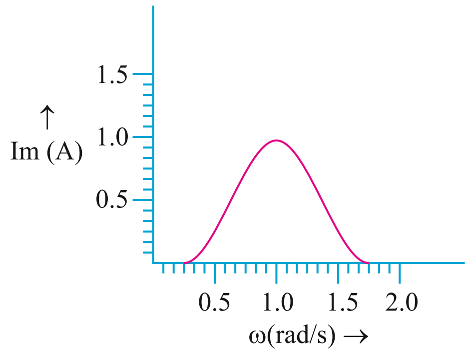
Again $\tan\phi = \dfrac{X_L - X_C}{R} = \dfrac{3}{4}$

$$X_L - X_C = \frac{3R}{4}$$

using this $R = 20\Omega;\ X_L - X_C = 15\Omega,\ I = \dfrac{V}{Z} = \dfrac{223}{25} = 8{\cdot}92$ A,

$$I_m = \sqrt{2}\ I = 12.6A$$

40. In a LCR circuit, the plot of I_{max} versus ω is shown in figure. Find the bandwith ?



Ans. $I_{rms} = \dfrac{I_{max}}{\sqrt{2}} = \dfrac{1}{\sqrt{2}} = 0.7$ At

from diagram $\omega_1 = 0.8$ rad/s

$\omega_2 = 1.2$ rad/s

$\Delta w = 1.2 - 0.8 = 0.4$ rad/s

41. An inductor of unknown value, a capacitor of 100μF and a resistor of 10Ω are connected in series to a 200V, 50Hz ac source. It is found that the power factor of the circuit is unity. Calculate the inductance of the inductor and the current amplitude.

Ans. $L = 0.10$ H, $I_0 = 28.3A$

42. A 100 turn coil of area 0.1 m^2 rotates at half a revolution per second. It is placed in a magnetic field of 0.01 T perpendicular to the axis of rotation of the coil. Calculate max. e.m.f. generated in the coil.

Ans. $\varepsilon_0 = 0.314$ Volt.

43. The magnetic flux linked with a large circular coil of radius R is 0.5 $\times 10^{-3}$ W*b*, when current of 0.5A flows through a small neighbouring coil of radius *r*. Calculate the coefficient of mutual inductance for the given pair of coils.

If the current through the small coil suddenly falls to zero, what would be the effect in the larger coil.

Ans. M = 1*m*H.

If the current through small coil suddenly falls to zero, [as, $e_2 = -M \dfrac{di_1}{dt}$] so initially large current is induced in larger coil, which soon becomes zero.

2 MARKS QUESTIONS

2. $S = \dfrac{I_g}{(I - I_g)} G = \dfrac{5 \times 10^{-3}}{5 - 5 \times 10^{3}} \times 120 = 0.12\Omega.$

3. (i) $-mB$ (ii) zero

4. (i) $B = \dfrac{10^{-7} \times \pi \times 10}{2 \times 10^{-2}} = 5\pi \times 10^{-5}$ T (inwards).

(ii) B = 5p × 10^{-5} T (inwards).

5. $r_p = \dfrac{mv}{qB}$ and $r_\alpha = \dfrac{4mv}{(2q)B} = 2r_\alpha \Rightarrow \dfrac{r_p}{r_\alpha} = \dfrac{1}{2}$.

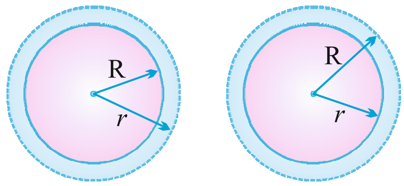
7. Low Retentivity and high permeability.

8. Minimum potential = – MB when θ = 0 (most stable position)

Maximum potential = MB when θ = 180º (most unstable position).

9. (a) Pole strength same; magnetic moment half.

(b) Pole strength half; magnetic moment half.



10. $$B\,(2\pi r) = \mu_0 \left[\frac{I}{\pi R^2}(\pi r^2)\right]$$

$$B = \left(\frac{\mu_0 I}{2\pi R^2}\right) r \qquad (R \geq r)$$

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

$$\therefore \qquad B = \frac{\mu_0 I}{2\pi r} \qquad (r \geq R)$$

11. $M_1 = NI\pi R^2;\ M_2 = NIa^2 \quad \therefore \quad \frac{M_2}{M_1} = \frac{a^2}{R^2}$

$2\pi r N = 4aN \Rightarrow a = \frac{\pi R}{2}$

$\frac{M_2}{M_1} = \pi/4$

12. $\frac{m_{new}}{m_{original}} = \frac{2I \times \pi\left(\frac{r}{2}\right)^2}{I \times \pi R^2} = \frac{1}{2}$ (As $N_2 = 2N_1$)

13. For P, $\theta = 0^0$ and Q, $\theta = 180^0$, hence, no torque Stable for P and unstable for Q.

16. (a) $\oint \vec{B}.d\vec{l} = \mu_0 I = 2\mu_0$ Tm

(b) zero

22. (i) $a = g$ because the induced emf set up in the coil does not produce any current and hence no opposition to the falling bar magnet.

(ii) $a < g$ because of the opposite effect caused by induced current.

23. Current at resonance $I = \frac{V}{R}$.

$\therefore$ Voltage across inductor $V_L = I.X_L = I\omega L = \frac{V}{R}(2\pi\nu) L.$

24. A.C. ammeter works on the principle of heating effect $H \propto I^2$.

25. Brightness of bulb depends on current. $P \propto I^2$ and

$$I = \frac{V}{Z} \text{ where } Z = \sqrt{X_c^2 + R^2} \text{ and}$$

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi\nu C}$$

$X_C \propto \frac{1}{C}$, when mica sheet is introduced capacitance C increases

$\left(C = \frac{K \epsilon_0 A}{d}\right)$,

X_C decreases, current increases and therefore brightness increases.

26. Current $I = \varepsilon/R$

In coil P, $I_1 = E_1/R = \frac{B\nu b}{R}$

In coil Q, $I_2 = E_2/R = \frac{B\nu l}{R}$ $\qquad$ $I_1/I_2 = \frac{b}{l}$.

27. Electro magnetic energy is conserved.

$$\mu_E(\max) = \mu_B(\max)$$

$$1/2\frac{Q^2}{C} = \frac{1}{2}LI^2$$

$$I = 637 \text{ mA}$$

28. 10^{-6} F.

40. No current is induced in coil A since angle is 90.

ANSWER FOR NUMERICALS

15. Force experienced by current carrying conductor in magnetic field.

$$F = I\vec{L} \times \vec{B} = IBL \sin\theta$$

Hence, force permit length, $f = \frac{F}{L}$ IB sin 30º

$= 8 \times 0.15 \times 1/2 = 0.6\ Nm^{-1}$

16. (a) Current sensitivity, $\frac{\phi}{I} = \frac{NBA}{K}$

Ratio of current Sensitivity $= \left(\frac{N_1B_1A_1}{K}\right) / \left(\frac{N_2B_2A_2}{K}\right)$

$= \frac{30 \times 0.25 \times 3.6 \times 10^{-3}}{42 \times 0.50 \times 1.8 \times 10^{-3}} = 5/7$

(b) Voltage sensitivity, $\frac{\phi}{V} = \frac{NBA}{kR}$

Ratio of voltage sensitivity $= \left(\frac{N_1B_1A_1}{kR_1}\right) / \left(\frac{N_2B_2A_2}{kR_2}\right)$

$= \frac{30 \times 0.25 \times 3.6 \times 10^{-3} \times 14}{42 \times 0.50 \times 1.8 \times 10^{-3} \times 10} = 1$

17. (a) For equilibrium, the dipole moment should be parallel or auto parallel to B. Hence, AB_1 and AB_2 are not in equilibrium.

(b) (i) for stable equilibrium, the dipole moments should be parallel, examples : AB_5 and AB_6 (ii) for unstable equilibrium, the dipole moment should be anti parallel examples : AB_3 and AB_4.

(c) Potential energy is minimum when angle between M and B is 0º, *i.e*, U = – MB Example : AB_6.

18. (a) Total resistance, $R_G + 3 = 63\Omega$.

Hence, $I = \frac{3V}{63\Omega} = 0.048A$

(b) Resistance of the galvanometer as ammeter is

$\frac{R_G r_S}{R_G r_S} = \frac{60\Omega \times 0.02\Omega}{(60 + 0.02)} = 0.02\Omega$

Total resistance $R = 0.02\Omega + 3\Omega = 3.02\Omega$

Hence, $I = \dfrac{3}{302} = 0.99A$.

(c) For the ideal ammeter, resistance is zero, the current, $I = 3/3 = 1.00A$.

19. From Biot-Savart's Law, $\left|\overrightarrow{d\beta}\right| = Id\ell \sin\theta\ /r^2$

$dI = \Delta x = 1$ cm $= 10^{-2}$ m, $I = 10A$, $r = y = 0.5$ m
$\mu_0/4\pi = 10^{-7}$ Tm/A, $\theta = 90°$ so $\sin\theta = 1$

$$\left|\overrightarrow{dB}\right| = \frac{10^{-7} \times 10 \times 10^{-2}}{25 \times 10^{-2}} = 4 \times 10^{-8} \text{ T along + z axis}$$

20. Force experienced by wire $F_m = BIl$ (due to map field)
The force due to gravity, $F_g = mg$

$$mg = BIl \Rightarrow B = mg/Il = \frac{0.2 \times 9.8}{2 \times 1.5} = 0.657 \text{ T}$$

[Earth's mag. field 4×10^{-5} T is negligible]

25. (i) $V_0 = 110$ volt

(ii) $V_{av1/2} = \dfrac{2V_0}{\pi} = \dfrac{2 \times 110 \times 7}{22} = 70$ volt.

26. Induced emf $\varepsilon = -N\dfrac{d\phi}{dt} = -25\dfrac{(1-6)\times 10^{-3}}{.5} = 0.25$ volt.

27. (i) Reactance $X_L = \omega L = 300 \times 4 \times 10^{-3} = 1.2\ \Omega$.

(ii) Peak Voltage $V_0 = i_0 X_L = 12 \times 1.2 = 14.4$ volt.

28. In ideal transformer $P_{in} = P_0$

$$V_P I_P = V_S I_S$$

$$\frac{V_S}{V_P} = \frac{I_P}{I_S} = \frac{N_S}{N_P} \qquad N_S = \left(\frac{V_S}{V_P}\right) N_P = \frac{240}{2400} \times 4000 = 400$$

29. Induced current $I = \varepsilon/R$

where $\qquad \varepsilon = \dfrac{-d\phi}{dt} = -10t + 4$

$\qquad \varepsilon = -10(15) + 4 = -146$ mV where $\qquad \phi = 5t^2 - 4t + 2$ and $R = 8\Omega$

$$\therefore \qquad I = -\frac{.146}{8} A = -.018A$$

30. When V and I in phase

$$X_L = X_C, \quad v = \frac{1}{2\pi}\frac{1}{\sqrt{LC}}$$

$$C = \frac{1}{4\pi^2 v^2 L} = \frac{1}{4\pi^2 \times 50 \times 50 \times \frac{4}{\pi^2}}$$

$$= 2.5 \times 10^{-5} = 25\ \mu F.$$

31. Current in the circuit $I = \dfrac{V}{Z}$

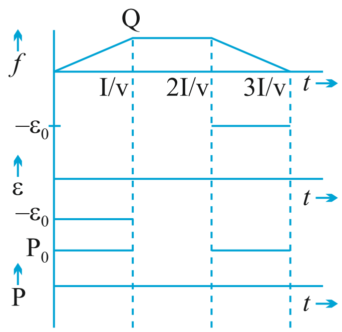
When $\qquad Z = \sqrt{X_C^2 + R^2}, \quad X_C = \dfrac{1}{\omega C} = \dfrac{1}{2\pi v C}$

Then total voltage across capacitor and resistor.

$$V_C = iX_C, \qquad V_R = IR.$$

(ii) $\qquad \tan\phi = \dfrac{X_C}{R}$ [V lags current]

32.



(i) $\phi = Blb$

(ii) $\varepsilon_0 = Bvb$

(iii) $P_0 = \dfrac{\varepsilon_0^2}{R}$

$$= \frac{B^2 v^2 b^2}{R}$$

33. (i) Frequency of current oscillations

$$v = \frac{1}{2\pi\sqrt{LC}}$$

(ii) Frequency of electrical energy oscillation $v_c = 2v$

(iii) Maximum current in the circuit $I_0 = \frac{q_0}{\sqrt{LC}}$

(iv) Magnetic energy in the inductor when charge on capacitor is $4mC$.

$$U_L = U - U_C = \frac{1}{2}\frac{q_0^2}{C} - \frac{1}{2}\frac{q^2}{C} = \frac{q_0^2 - q^2}{2C}$$

Here $q_0 = 5mC$; $q = 4mC$

34. Current in the circuit :

(i) $I = \frac{V}{Z}$, where $Z = \sqrt{X_L^2 + R^2}$

(ii) RMS voltage across L and R

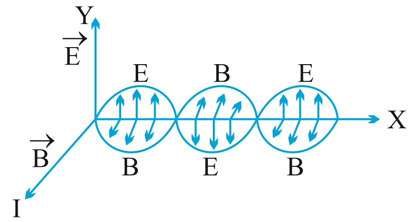
$V_L = I \,.\, X_L$; $V_R = IR$

(iii) $(V_L + V_R) > V$ because V_L and V_R are not in same phase.

Unit V & VI
ELECTROMAGNETIC WAVES AND OPTICS

KEY POINTS

1. EM waves are produced by accelerated (only by the change in speed) charged particles.
2. $\vec{E}$ and $\vec{B}$ vectors oscillate with the frequency of oscillating charged particles.
3. Propagation of wave along x-direction.



4. Properties of em waves :
   (i) Transverse nature
   (ii) Can travel though vacuum.
   (iii) $\dfrac{E_0}{B_0} = \dfrac{E}{B} = \lambda v = C$ $\qquad$ C $\rightarrow$ Speed of EM waves.
   (iv) Speed of em wave C = 3 × 10^8 m/s in vacuum and

$$C = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = 3 \times 10^8 \text{ m/sec (in vacuum)}$$

(v) In any medium $v = \frac{1}{\sqrt{\mu\varepsilon}}$

Where $\mu = \mu_r \mu_0$ $\varepsilon = \varepsilon_r \varepsilon_o$

$\sqrt{\varepsilon_r} = n$ refractive index of medium

Also $v = \frac{c}{n}$

(vi) A material medium is not required for the propagation of e.m. waves.

(vii) Wave intensity equals average of Pointing vector $I = |\vec{S}|_{av} \frac{B_0 E_0}{2\mu_0}$.

(viii) Average electric and average magnetic energy densities are equal.

$U_E = \frac{1}{2}\varepsilon_0 E^2$ and $U_B = \frac{1}{2}\frac{B^2}{\mu_0}$

(ix) The electric vecotr is responsible for optical effects due to electro magnetic wave. For this reason, electric vector is called light vector.

- In an em spectrum, diffferent waves have different frequency and wavelengths.
- Penetration power of em waves depends on frequency. Higher, the frequency larger the penetration power.
- Wavelength λ and frequency v are related with each other $v = v\lambda$. Here V is the wave velocity.
- A wave travelling along $+x$ axis is represented by

$$E_y = E_0 \cos(\omega t - kx)$$

$$B_z = B_0 \cos(\omega t - kx)$$

$$\omega = \frac{2\pi}{T} = 2\pi v$$

$$\frac{\omega}{k} = \lambda v = V = C \text{ wave speed}$$

$$k = \frac{2\pi}{\lambda} = 2\pi\bar{v}$$

$$v \rightarrow \text{frequency}$$

$$\bar{v} = \frac{1}{\lambda} \text{ wave number.}$$

Electromagnetic Soectrum

Name	Wavelength range	Production	Uses
Gamma Rays	$< 10^{-12}$ m	Gamma rays produced in radio active decay of nucleus	in treatment of cancer and to carry out nuclear reactions.
x-rays	10^{-9} m to 10^{-12} m	*x*-ray tubes or inner shell electrons	used as diagnostic tool in medical to find out fractures in bones. to find crack, flaws in metal part of machine
UV rays	4×10^{-7} to 10^{-9} m	by very hot bodies like sun and by UV lamps	in water purifier in detection of forged documents, in food preservation.
Visible light	7×10^{-7} m to 4×10^{-7}m	by accelerated tiny (electrons) charge particles	to see every thing around us
IR rays	10^{-3} m to 7×10^{-7} m	due to vibration of atoms	in green houses to keep plant warm to reveal secret writings on walls in photography during fog and smoke
Microwaves	10^{-1} m to 10^{-3} m	produced in klystron Valve and magnetron Valve	in RADAR in microwave ovens
Radio waves	> 0.1 m	by accelerated charged particles excited electrical circuits excited	in radio telecommunication system in radio astrology

Displacement Current—Current produced due to time varying electric field or electric flux.

$$I_D = \varepsilon_0 \frac{d\phi_e}{dt}, , \ \phi_e \text{ is electric flux}$$

Modified Ampere's Circuital law by Maxwell

$$\oint \vec{B}.d\vec{l} = \mu_0\left(I_C + \varepsilon_0 \frac{d\phi_e}{dt}\right)$$

$$I_c \rightarrow \text{Conduction current}$$

$$I_C = I_D$$

OPTICS
RAY OPTICS

GIST

1. REFLECTION BY CONVEX AND CONCAVE MIRRORS

a. Mirror formula $\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$ where u is the object distance, v is the image distance and f is the focal length.

b. Magnification $m=-\frac{v}{u}=\frac{f-v}{f}=\frac{f}{f-u}$ m is $-ve$ for real images and $+ve$ for virtual images.

c. Focal length of a mirror depends up only on the curvature of the mirror $\left(f=\frac{R}{2}\right)$. It does not depend on the material of the mirror or on wave length of light.

2. REFRACTION

d. Ray of light bends when it enters from one medium to the other, having different optical densities.

When light wave travels from one medium to another, the wave length and velocity changes but frequency of light wave remains the same.

e. Sun can be seen before actual sunrise and after actual sun set due to Atmospheric refraction.

f. An object under water (any medium) appears to be raised due to refraction when observed obliquely.

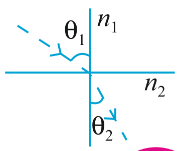
$n=\frac{\text{Real depth}}{\text{apparent depth}}$ n ◦ refractive index

and normal shift in the position (apparent) of object is

$x=t\left\{1-\frac{1}{n}\right\}$ where t is the actual depth of the medium.

g. Snell's law states that for a given colour of light, the ratio of sine of the angle of incidence to sine of angle of refraction is a constant, when light travels from one medium to another.

$n_1 \sin\theta_1 = n_2 \sin\theta_2$



h. Absolute refractive index is the ratio between the velocities of light in vacuum to velocity of light in medium. For air regractive index is 1.003 for practical uses taken to be 1

$$n = \frac{c}{v}$$

3. T.I.R.

i. When a ray of light travels from denser to rarer medium and if the angle of incidence is greater than critical angle, the ray of light is Reflected back into the denser medium. This phenomenon is called total internal refiection. (T.I.R.)

$$\sin C = \frac{n_R}{n_D}$$

Essential conditions for T.I.R.

1. Light should travel from denser to rarer medium.
2. Angle of incidence must be greater than critical angle $(i > i_C)$

j. Diamond has a high refractive index, resulting with a low critical angle $(C = 24.4^0)$. This promotes a multiple total internal reflection causing its brilliance and luster. Working of an optical fibre and formation of mirage are the examples of T.I.R.

4. When light falls on a spherical refracting surface, from rarer to denser medium the relation among, u, v and R is given by $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$.

5. Lens maker formula for a thin lens is given by

$$\frac{1}{f} = \left(\frac{n_2 - n_1}{n_1}\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

For Convex Lens R_1 + ve; R_2 – ve and Concave lens R_1 –ve; R_2 + ve. The way in which a lens behaves as converging or diverging depends upon the values of n_2 and n_1.

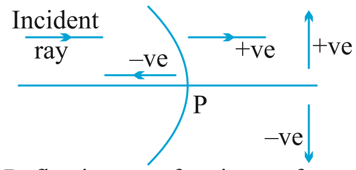
6. When two lenses are kept in contact the equivalent focal length is given by

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} \text{ and Power } P = P_1 + P_2$$

Magnification $m = m_1 \times m_2$

7. The lens formula is given by $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

Sign convention for mirrors and lenses → Distances in the direction of incident ray are taken as positive. All the mesurement is done from pole (P).



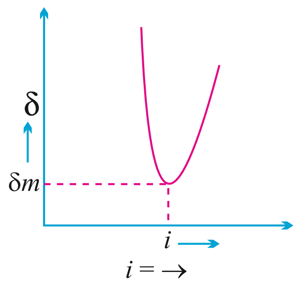
Reflecting or refracting surface

8. When ray of light passes through a glass prism it undergoes refraction, then $A + \delta = i + e$ and, the expression of refractive index of glass prism

$$n = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

As the angle of incidence increses, the angle of deviation decreases, reaches a minimum value and then increases. This minimum value of angle of deviation is called angle of minimum deviation "δ_m".

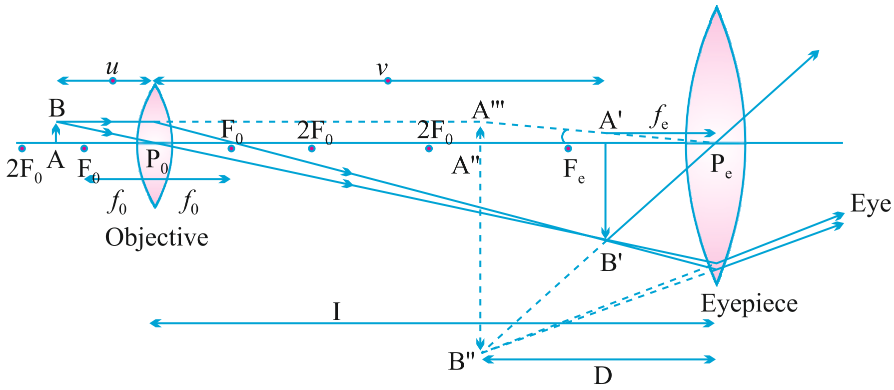
9.



Where δ is minimum, $i = e$, refracted ray lies parallel to the base. For a small angled prism d min = $(n – 1)$A.

10. When white light is passed through a glass prism, it splits up into its constituent colours (Monochromatic). This phenomenon is called Dispersion.

Compound Microscope :



Objective : The converging lens nearer to the object.
Eyepiece : The converging lens through which the final image is seen.
Both are of short length. Focal length of eyepiece is slightly greater than that of the objective.

4. Angular Magnification or Magnifying Power (M) :

$$\mathbf{M = M_e \times M_o}$$

(a) When final is formed atleast distance of distinct vision.

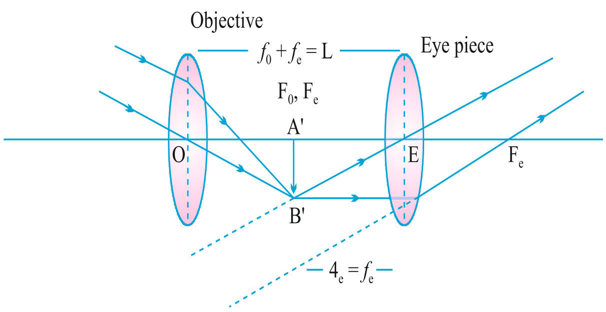
$$\boxed{M = \frac{v_0}{-u_0}\left(1+\frac{D}{f_e}\right)} \quad \boxed{M = \frac{-L}{f_0}\left(1+\frac{D}{f_e}\right)}$$

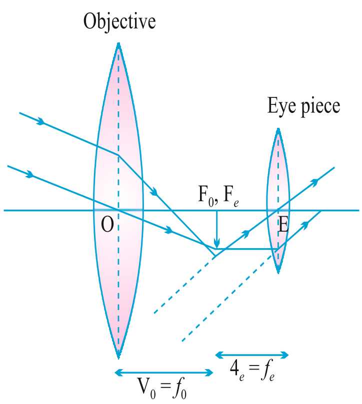
(b) When final image is formed at infinity $M = \dfrac{-L}{f_O}\dfrac{D}{f_e}$

(Normal adjustment *i.e.* image at infinity) Length of tube

$$L = |v_o| + |u_e|$$

5. Formation of Image by Astronomical Telescope : at infinity Normal Adjustment Position)





Focal length of the objective is much greater than that of the eyepiece. A perture of the objective is also large to allow more light to pass through it.

6. **Angular magnification or Magnifying power of a telescope.**

(a) When final image is formed at infinity (Normal adjustment)

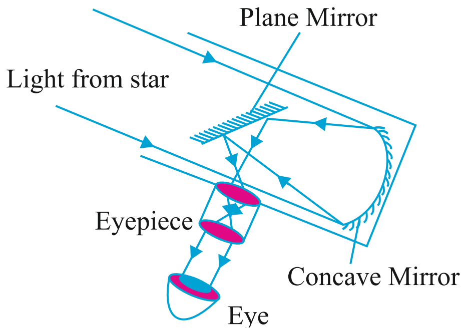
$$\boxed{M=\frac{\beta}{\alpha}} \qquad \boxed{M=\frac{-f_o}{f_e}}$$

($f_o + f_e$ = L is called the length of the telescope in normal adjustment).

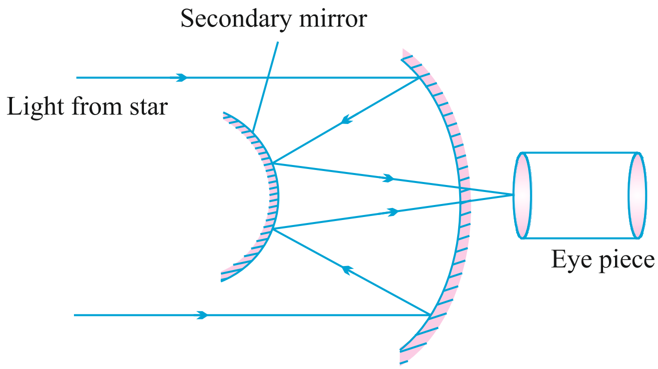
(b) When final image is formed at least distance of distinct vision.

$$m=\frac{-f_o}{f_e}\left(1+\frac{f_o}{D}\right) \text{ and } L=f_o+|u_e|$$

7. **Newtonian Telescope : (Reflecting Type)**



8. **Cassegrain telescope** be



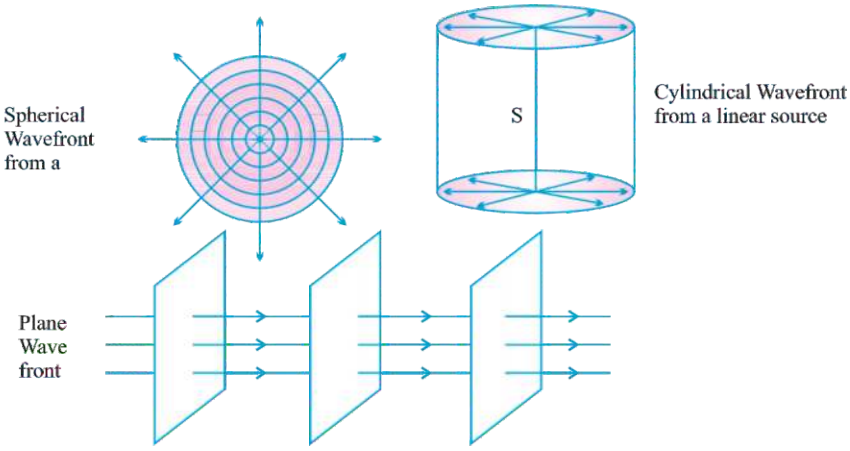
WAVE OPTICS

Wave front :

A wavelet is the point of disturbance due to propagation of light.

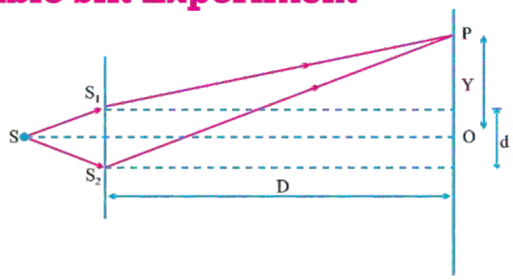
A wavefront is the locus of points (wavelets) having the same phase of vibrations.

A perpendicular to a wavefront in forward direction is called a ray.



INTERFERENCE OF WAVES

Young's Double Slit Experiment



The waves from S_1 and S_2 reach the point P with some phase difference and hence path difference

$$\Delta = S_2P - S_1P$$

$$S_2P^2 - S_1P^2 = \left[D^2 + \left\{y + \left(\frac{d}{2}\right)\right\}^2\right] - \left[D^2 + \left\{y - \left(\frac{d}{2}\right)\right\}^2\right]$$

$$(S_2P - S_1P)\,(S_2P + S_1P) = 2\,yd \qquad S_2P \approx S_1P \approx D$$

$$\Delta\,(2D) = 2\,yd$$

$$\Delta = \frac{yd}{D}$$

Interference phenomenon

1. Resultant intensity at a point on screen

$$I_R = K\,(a_1^{\,2} + a_2^{\,2} + 2a_1a_2\cos\phi)$$

$$I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi \qquad \text{Where } I_1 = ka_1^2,\quad I_2 = ka_2^2$$

$$\text{If } I_1 = I_2 = I_o, \text{ then } I_R = 4I_o\cos^2\left(\frac{\phi}{2}\right)$$

2. $I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$ If $I_1 = I_2 = I_0$, $I_{max} = 4I_0$

   $I_{min} = \left(\sqrt{I_1} - \sqrt{I_1}\right)^2$ If $I_1 = I_2 = I_0$, $I_{max} = 0$

3. $$\frac{I_{max}}{I_{min}} = \frac{\left(\sqrt{I_1} + \sqrt{I_2}\right)^2}{\left(\sqrt{I_1} - \sqrt{I_2}\right)^2}$$

4. $$\frac{I_{max}}{I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2}$$

5. $\dfrac{I_1}{I_2} = \dfrac{a_1^2}{a_2^2} = \dfrac{w_1}{w_2}$, w_1 and w_2 are widths of two slits

6. Constructive interference

   Phase difference, $\phi = 2n\pi$

   Path difference, $x = n\lambda$

   Destructive interference

   Phase difference $\phi = (2n + 1)\pi$

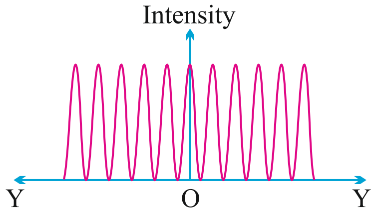
   Path difference $x = (2n+1)\dfrac{\lambda}{2}$

   Where $n = 0, 1, 2, 3, \ldots\ldots$

7. Fringe width (dark or bright) $\beta = \dfrac{\lambda D}{d}$

   Angular width of fringe $\Delta\theta = \dfrac{\beta}{D} = \dfrac{\lambda}{d}$

Distribution of Intensity

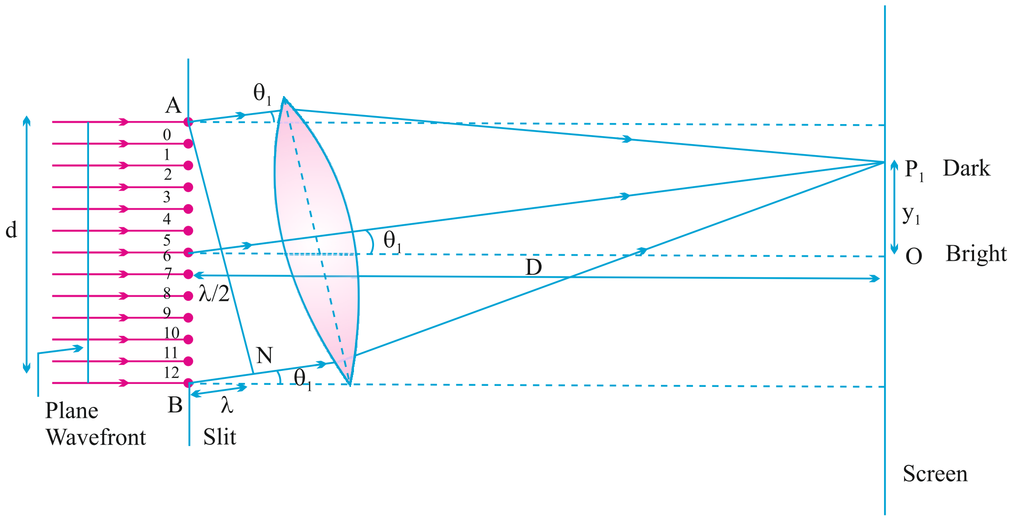


Conditions for Sustained Interference :

1. The two sources must be coherent.
2. The two interfering wave trains must have the same plane of polarisation.
3. The two sources must be very close to each other and the pattern must be observed at a large distance to have sufficient width of the fringe $b = \dfrac{\lambda D}{d}$ Angnlar width $a = l/d$
4. The sources must be monochromatic. Otherwise, the fringes of different colours will overlap.
5. The two waves must be having same amplitude for better contrast between bright and dark fringes.

DIFFRACTION OF LIGHT AT A SINGLE SLIT :

Width of Central Maximum :



$$y_1 = \frac{D\lambda}{d}$$

Since the Central Maximum is spread on either side of O, the width is

$$\boxed{\beta_0 = \frac{2D\lambda}{d}}$$

Fresnel's Distance :

$$y_1 = \frac{D\lambda}{d}$$

At Fresnel's distance, $y_1 = d$ and $D = D_F$

So, $$\frac{D_F \lambda}{d} = d \text{ or } D_F = \frac{d^2}{\lambda}$$

QUESTIONS

SECTION - A

VERY SHORT ANSWER QUESTIONS (I Mark)

1. In which situation is there a displacement current but no conduction current between plates capacitor?
   (a) Only during charging of parallel plate capacitor
   (b) Only during discharging of paralle plate capacitor
   (c) Only during charging or discharging of parallel plate capacitor
   (d) This will never happen
2. The charging current for a capacitor is 0.25A. What is the displacement current across its plates?
   (b) 5A (b) 0.25A
   (c) 0.125A (c) 1A
3. A plane electromagnetic wave travels in vacuum along z-direction. The directions of electric field vector and magnetic field vector will be
   (a) electric field along x-axis, Magnetic field along y-ans
   (b) electric field along x-axis, Magnetic field along x-axis
   (c) electric field along y-axis, Magnetic field along y-awis
   (d) electric field along y-axis, Magnetic field along x-axis

4. Which part of electromagnetic wave are used in operating 'RADAR'

(a) Infrared waves
(b) Microwaves X-Rays
(d) x-Rays
(d) Gamma Rays

5. The change on parallel plate capacitor varies as $q = q_0 \cos 2\pi vt$. The plates are very lagrge and close together. Neglecting the edge effect, find the displacement current through the capacitor?

(a) $2\pi q_0 v \sin 2\pi vt$
(b) $-2\pi q_0 v \sin 2\pi vt$
(c) $2\pi q_0 v \cos 2\pi vt$
(d) $-2\pi q_0 v \cos 2\pi vt$

6. For the same value of angle of incidence, the angle of refraction in three media A, B, and C are 15°, 25° and 35° respectively. The velocity of light will be minimum in-

(a) A
(b) B
(c) C
(d) same in all media

7. Which of the following statement is not true.

(a) Optical fibre is based on the principle of total internal reflection.
(b) The refractive index of the material of the core is less than that of the cladding
(c) an optical fibre can be used to act as an optical pipe
(d) there is no appreciable loss in the intensity of the light signal while propagating through an optical fibre

8. A thin converging lens of focal length 10 cm and a thin diverging lens of focal length 20 cm are placed coaxially in contact. The power of the combination is:

(a) –5 D
(b) +5 D
(c) +15D
(d) 15D

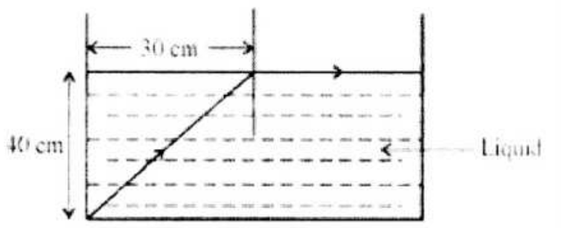
9. A diamond is immersed in a liquid with a refractive index greater than water. Then the critical angle for total internal reflection will

(a) Increase
(b) Decrease
(c) Depend on the nature of the liquid
(d) Remains the same

10. Which of the following correctly define refractive index of a medium.

(a) Real depth/App depth
(b) App depth/ Real depth
(c) App depth × Real depth
(d) Real depth + App depth

11. The magnification due to a compound microscope does not depend upon
   (A) the aperture of the objective and the eye-piece
   (b) the focal length of the objective and the eye-piece
   (c) the length of the tube
   (d) the colour of the light used



12. In the above diagram, calculate the speed of light in the liquid of unknown refractive index.
   (a) 1.2×10^8 m/s (b) 14×10^8 m/s
   (c) 1.6×10^8 m/s (d) 18×10^8 m/s
13. A mirror forms 3 times magnified image of an object. The mirror can be-
   (a) Concave (b) convex
   (c) Plane (d) both convex and concave
14. Focal length of a convex mirror is 20 cm. it forms1/2 times magnified virtual image of an object. The image distance is:
   (a) 30 cm (b) 10 cm
   (c) 20/3 cm (d) 40/3 cm
15. A magician puts some glass object into a liquid. the object gets disappeared. Then,
   (a) the refractive index of object is more than that of liquid
   (b) the refractive index of object is less than that of liquid
   (c) the refractive index of object is equal to that of liquid
   (d) data insufficient
16. The phenomena which is not explained by Huygen's construction of wavefront
   (a) reflection (b) diffraction
   (c) refraction (d) photo electric effect

17. Two slits in Young's double slit experiment have widths in the ratio 36:1. The ratio of the amplitudes of light waves is

(a) 3 :1 (b) 3:2

(c) 9:1 (d) 6:1

18. Which of the following is true for interference of light

(a) energy is created in the region of bright band

(b) energy is destroyed in the region of dark band

(c) conservation of energy does not hold good

(d) conservation of energy holds good and energy is redistributed

19. In Young's Double Slit experiment using sodium light (λ = 5898 Å), 92 fringes are seen. If greenish colour (5480 Å) is used, how many fringes will be seen?

(a) 62 (b) 99

(c) 67 (d) 85

20. Two coherent monochromatic light beams of intensities I and 91 are superimposed. The maximum and minimum possible intensities in the resulting beam are

(a) 9I and I (b) 161 and 41

(c) 91 and 31 (d) 5I and 31

21. A diffraction pattern is obtained by using a beam of blue light. What will happen if the blue light is replaced by the red light

(a) No change will take place

(b) Bands become broader and farther apart

(c) Bands disappear

(d) Diffraction bands become narrower and crowded

22. Two waves, originating from sources S_1 and 5_2 having zero phase difference and common wavelength λ, will show completely destructive interference at a point P if $(S_2P - S_1P)$ is

(a) $(13/2)\lambda$ (b) 3A

(c) 4λ (d) $(5/4)\lambda$

23. Light of wavelength λ falls normally on a slit of width 'a'. The diffraction due to slit will be most prominently observed when-

(a) $a = 5\lambda$ (b) $a = 50\lambda$

(c) $a = 500\,\lambda$ (d) $a = 5000\,\lambda$

24. Nishchay performs YDSE by using yellow, blue and red lights in turn. If the fringe width measures in three cases are x_1, x_2 and x_3, respectively, then which of the following is correct?

(a) $x_1 > x_2 > x_3$ (b) $x_3 > x_1 > x_2$

(c) $x_2 > x_1 > x_3$ (d) $x_1 < x_2 < x_3$

25. When monochromatic light is replaced by white light in a single slit experiment, then

(a) the diffraction pattern disappears

(b) the diffraction band becomes circular

(c) a white band is formed at the centre and coloured bands are formed at both its sides

(d) only a white band is formed at the centre

26. If in a diffraction experiment, the width of the slit is slightly increased, then the central maximum of the diffraction pattern becomes:

(a) broader and brighter

(b) broader and fainter

(c) narrow and brighter

(d) narrow and fainter

27. A parallel beam of light of wavelength 500 nm falls on a narrow slit. The diffraction pattern is observed on a screen 1 m away. The first minimum is at a distance of 2.5 mm from the centre of the screen. The width of the slit is:

(a) 0.16 mm (b) 0.20 mm

(c) 0.40 mm (d) 0.60 mm

28. Two sources of light are said to be coherent, when both emit light waves of:

(a) same amplitude and have a varying phase difference.

(b) same wavelength and a constant phase difference.

(c) different wavelengths and same intensity.

(d) different wavelengths and a constant phase difference.

29. The fringe width in YDSE is β. If the whole set-up is immersed in a liquid of refractive index n , then the new fringe width will be :

(a) β (b) β/n

(c) βn (d) β/n^2

30. The total path difference between two waves meeting at points P_1 and P_2 on the screen are $3\lambda/2$ and 2λ respectively. Then :

(a) bright fringes are formed at both points

(b) dark fringes are formed at both points.

(c) a bright fringe is formed at P_1 and a dark fringe is formed at P_2

(d) a bright fringe is formed at P_2 and a dark fringe is formed at P_1

Answers

1. (c)	2. (b)
3. (a)	4. (b)
5. (b)	6. (a)
7. (b)	8. (b)
9. (a)	10. (a)
11. (a)	12. (c)
13. (a)	14. (c)
15. (b)	16. (d)
17. (d)	18. (d)
19. (b)	20. (b)
21. (a)	22. (a)
23. (b)	24. (c)
25. (c)	26. (c)
27. (b)	28. (b)
29. (b)	30. (d)

Assertion And Reason : (Unit V)

In the following questions, a statement of assertion A is followed by a statement of reason R. Mark the correct choice as :

a) If both assertion and reason are correct and reason is the correct explanation of assertion.

b) If both assertion and reason are correct and reason is not the correct explanation of assertion.

c) If assertion is true but reason is false.

d) If both assertion and reason are false.

Reason - Assertion Question (Option)

31. Assertion : When entire experimental set-up is immersed in water, the fringes became less wider in young's double shit experiments.

    Reason : Wave length of light decreases when it travels from rarer to denser medium. Ans. (a)

32. Assertion : Two light sources emitting light waves of equal amplitude, equal frequency and equal wavelength all called coherent sources.

    Reason: Phase difference between any to sources is always constant.

    Ans. (d)

33. Assertion : The objective of on astronomical telescope is taken of larger focal length to increase magnifying power. Ans. (d)

    Reason : The normal adjustment mode in preferred over near point vision on image formed at infinity in now comfortable to view due to relaxed eye.

    Ans. (b)

34. Assertion : A white light when passed through a prism ut splits its constituent colours.

    Reason : All colours travels with same speed in a particular medium. Ans. (c)

35. Assertion : Electromagnetic waves exert pressure.

Reason : Electromagnetic waves carry both momentum and energy.

(Ans. b)

36. Assertion : Microwave communication is preferred over optical communication.

Reason : Microwaves provide large band width compared to optical signals.

(Ans. d)

37. Assertion : Electromagnetic waves don't require medium for propagation.

Reason : Electromagnetic waves can't travel in medium.

(Ans. c)

38. Assertion : Microwaves are preferred over Radio waves for satellite communication.

Reason : Microwaves have low wavelength than Radio waves.

(Ans. b)

39. Assertion : The intensity of solar radiation is greater Mars as compared to Jupiter.

Reason : The intensity of solar radiation is inversely proportional to the square of radius ($\frac{1}{r^2}$) of the planet. Ans. (a)

$$I \propto \frac{1}{r^2}$$

Case - Study Question (Option)(Unit VI)

I. Lens is a transparent medium bounded by two refracting surfaces. It can be converging or diverging. The converging or diverging behaviour a lens is dependent on refractive index of surrounding medium focal length of a lens is given by

$$\frac{1}{f} = \left[\frac{n_2}{n_1} - 1\right]\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

This is called lens maker's formula. It is useful to design lenses of designed focal length using surface of suitable radii of curvature.

1. A convex lens is-
   a) Always converging
   b) Always diverging
   c) Converging when placed in a rarer medium wrt medium lens.
   d) Converging when placed in a denser medium wrt medium lens.
2. An equiconvex lens is cut into equal halves perpendicular to the principal axis. If focal length of original lens in f, then focal length of each halve is -
   a) f
   b) f/2
   c) 2f
   d) $\frac{3}{2}$ f
3. A concave lens is made with a material of refractive index 1.52. It is placed in a medium of refractive index 1.60. The nature of lens would be-
   a) Converging
   b) Diverging
   c) Can be converging as well as diverging
   d) Neither converging nor diverging
4. A convex lens of refractive index 1.5 is immersed in a liquid medium. The lense gets disappeared in this medium, the refractive index of the medium is-
   a) More than 1.5
   b) Less than 1.5
   c) Equal to 1.5
   d) Can take any value between 1 to infinity.
5. In a particular medium, a convex lens behave as converging lens and concave lens as diverging lens. Now the two lens are put in contact with other. The nature of combination would be-

a) Converging only

b) Either converging or diverging

c) Neither converging nor diverging

d) Both b) & c) are possible

Ans. 1. (c), 2. (b), 3. (b), 4. (c), 5. (d)

II. When an opaque object is placed in the path of light rays, we see a shadow of object on a screen under some specific condition, we see a bright spot at the centre of geometrical shadow region. This happens due to a phenomenon called diffraction. Diffraction is a characteristic shown by all types of waves. When the double slit in young's experiment is replaced by a single narrow slits (illuminated by a monochromatic source), a broad pattern with a central bright region is seen, on either sides, there are alternate dark and bright regions.

1. The size of an opaque object is 0.5μm. Which of the following wave would exhibit diffraction pattern on the screen.

   a) Red light

   b) Yellow light

   c) Green light

   d) Orange light

2. Which of the following is "INCORRECT".

   a) In YDSE light waves from two different wave fronts superposed on each other to produce interference pattern.

   b) In single slit experiment light wave from different parts of same wave front superposed to produce different pattern.

   c) The intensity of bright bands in YDSE is same for all

   d) The intensity of all maxima's single shit experiment in same

3. In a single slit experiment, the screen is moved away from the plane of slits such that distance between screen and slit is doubled. The angular width of central maxima would-

a) Become 4 times (b) Remain unchanged

c) Become 2 times (d) Become ½ times

4. Which the following can be explained by both wave nature and particle nature of light-

 a) Diffraction

 b) Reflection of light

 c) Reflection of light

 d) Both reflection and refraction of light

Ans. 1. (c), 2. (d), 3. (b), 4. (d)

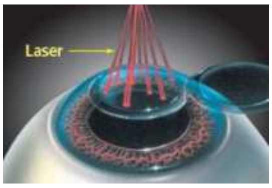
(UNIT : V)

Case Study

III. LASIK (Laser-assisted in Situ Keratomileusis).

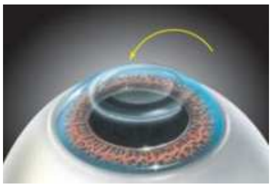
It is commonly know as Laser Eye Surgery for the correction of myopia, hyper metropia and astigmatism. For clear vision the eye's cornea and lens must refract light rays properly. This allows images to be focused on retina properly. Else images will be blurry. This blurriness is known as refractive error.

Lasik uses an excimer laser (An Ultra violet laser) to remove a thin layer of cornea tissue. LASIK causes the cornea to be thinner.



Flap
A special surgical knife slices a flap open on the surface of the cornea.

Cornea
Once tissue has been removed, the flap is folded back onto the cornea and heals quickly.



UV Laser
Pulses of ultraviolet laser light vaporise surface tissue, reshaping the cornea.

Retina
After surgery, light rays entering the eye are focused to a point on the retina, producing a much cleared image.

This gives the cornea a new shape so that light rays are focused on retina clearly. It reduces a person's need for glasses or contact lenses.

1. The frequency range of ultra violet rays is

   a) 10^{10} Hz - 10^{11} Hz

   b) 10^{12} Hz - 10^{15} Hz

   c) 10^{15} Hz - 10^{17} Hz

   d) 10^{18} Hz - 10^{21} Hz

2. Which of the following are not E.M radiations?

   a) Gamma rays

   b) Ultra violet rays

   c) Heat rays

   d) Beta rays

3. The structure of solids is investigated by using

   a) Microwave

   b) Ultra violet rays

   c) X-rays

   d) Gamma rays

4. The energy possessed by per photon of ultra violet radiation is about

   a) 12.41 eV b) 12.4 KeV

   c) 12.4 MeV d) 12.4 meV

5. The electromagnetic radition produced by electric arcs and lights like mercury vapor lamps used to ionise atoms is

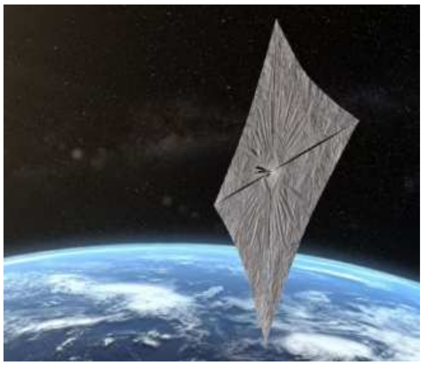
   a) Infrared radiation b) X-rays

   c) UV radiation d) Microwave

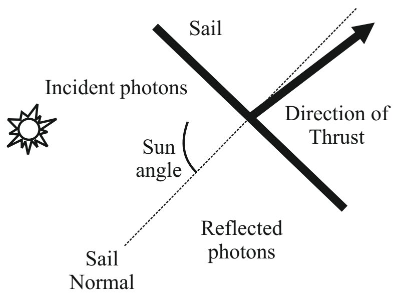
Answers

1. c)
2. d)
3. c)
4. a)
5. c)

Solar Sails :



Solar sails are a method of space craft propulsion using "Radiation Pressure" exerted by sunlight on large scales mirrors. Solar pressure affects all space crafts, whether in inter planetary space or in orbit around a planet. A typical space-craft going to Mars, for example, will be displated thousands of kilometers by solar pressure, so the effects must be accounted for in trajectory planning. Solar pressure also affects the orientation of a space craft. If a radiation falls on the surface (100% reflection) at on angle then, force will be $F = \frac{2P}{c}$ cos where P is power of radiation.



$$\rightarrow \text{Pressure} = \frac{f}{A} \rightarrow \frac{F}{A} = \frac{2P}{Ac} \cos$$

$$\rightarrow (\text{Radiation Pressure} = 2\frac{I}{c} \cos)$$

1. The intensity of solar radiation on Earth's surface is 1360 W/m^2. How much pressure will be exerted on a surface (100% reflecting) incident normally, approx.

   a) 9. Pa b) 9 mPa

   c) 9 Pμa d) 9 kPa

2. If a beam of EM wave is completely absorbed by the surface, then the pressure exited by radiation (Radiation Pressure) will be

a) $\frac{I}{c}$ b) $P=\frac{2I}{c}$ c) $P=\frac{I}{2c}$ d) P=o

3. A point source of EM waves emit the waves iso tropically in all directions. The intensity of wave at distance r from a point source of power P_s is

a) $I=\frac{P_s}{r^2}$ b) $I=\frac{P_s}{\pi r^2}$ c) $I=\frac{P_s}{4\pi r^2}$ d) $I=\frac{P_s}{2\pi r}$

4. The time-averaged rate per unit area at which energy is transported is intensity I of the wave can be expressed as

a) $I=\frac{2E^2_{rms}}{c\mu o}$ b) $I=\frac{E^2_{rms}}{c\mu o}$ c) $I=\frac{E^2_{rms}}{\mu o}$ d) $I=\frac{E^2_{rms}}{2c}$

5. Find the intensity of radiation at distance 7m from the source of 14 W.

a) 0.02 w/m^2 b) 0.2 w/m^2 c) 44 w/m^2 d) 4.4 w/m^2

Answers :

1. a) 2. a) 3. c) 4. b) 5. a)

SHORT ANSWER QUESTIONS (2 Marks)

1. Give one use of each of the following

(i) UV ray (ii) γ-ray.

2. Represent EM waves propagating along the x-axis in which electric and magnetic fields are along y-axis and z-axis respectively.

3. State the principles of production of EM waves. An EM wave of wavelength λ goes from vacuum to a medium of refractive index *n*. What will be the frequency of wave in the medium?

4. An EM wave has amplitude of electric field E_0 and amplitude of magnetic field is B_0. The electric field at some instant become $\frac{3}{4}E_0$. What will be magnetic field at this instant? (Wave is travelling in vacuum).

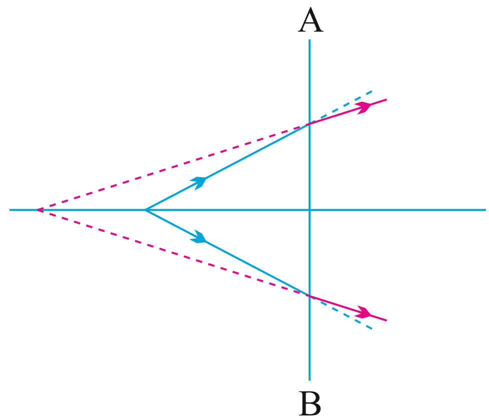
5. State two applications of infrared radiations.

6. State two applications of radio waves.

7. State two applications of x-rays.

8. Show that the average energy density of the electric field $\vec{E}$ equals the average energy density of the magnetic field $\vec{B}$?

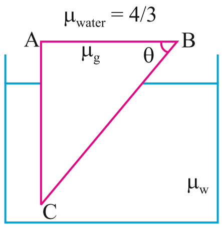
9. The line AB in the ray diagram represents a lens. State whether the lens is convex or concave.



10. Use mirror equation to deduce that an object placed between the pole and focus of a concave mirror produces a virtual and enlarged image.

11. Calculate the value of θ, for which light incident normally on face AB grazes along the face BC.

$\mu_{glass} = 3/2$ and $\mu_{water} = 4/3$



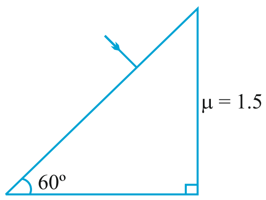
12. What is the effect on the interference fringes is YDSE when

(i) the screen is moved away from the plane of the slits (ii) the sepration between the two slits is increased

Ans. (i) As $\beta = \dfrac{\lambda D}{d}$; $\beta \propto D$ Therefore β increases

(ii) however angular sepration $\left(\dfrac{\lambda}{d}\right)$ remains same when d increases β decreases

13. Complete the path of light with correct value of angle of emergence.

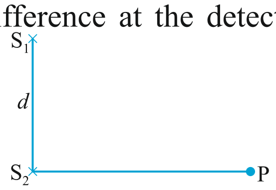


14. Define diffraction. What should be the order of the size of the aperture to observe diffraction.

15. Show that maximum intensity in interference pattern is four times the intensity due to each slit if amplitude of light emerging from slits is same.

16. Two poles-one 4 m high and the other is 4.5 m high are situated at distance 40 m and 50 m respectively from an eye. Which pole will appear taller?

17. S_1 and S_2 are two sources of light separated by a distance d. A detector can move along S_2P perpendicular to S_1S_2. What should be the minimum and maximum path difference at the detector?



18. If a jogger runs with constant speed towards a vehicle, how fast does the image of the jogger appear to move in the rear view mirror when

(i) the vehicle is stationery

(ii) the vehicle is moving with constant speed towards jogger.

Ans. The speed of the image of the jogger appears to increase substantially though jogger is moving with constant speed.

Similar phenomenon is observed when vehicle is in motion.

19. Why is interference pattern is not detected when two coherent sources are (i) far apart (ii) infinitely close to each other

Ans. (i) We know $\beta \alpha \frac{l}{d}$; since d is very large β may reduce so much i.e beyond visible region.

(ii) Since d is two small, β becomes very large. field of view may even be occupied by single slit on screen resulting no detection of pattern.

20. A parallel beam of light of wavelength 600 nm is incident normally on a slit of width 'd'. if the distance between the slit and screen is 0.8m and distance of 2nd order maximum from the centre of screen is 15 mm, calculate the width of the slit.

$$\text{Since} \quad \alpha \text{ sing } \theta = (2n+1)\frac{\lambda}{2} \quad \alpha \left(\frac{X}{d}\right) = (2x2+1)\ \lambda/2$$

$$\alpha = \frac{5\lambda D}{2\chi} = \frac{5x(6x10^{-7})x0.8D}{2x15x10^{-3}} = 0.8x11^{-4}m = 80\ \mu m$$

21. When does (i) a plane mirror and (ii) a convex mirror produce real image of objects.

Ans. Plane and convex mirror produce real image when the object is virtual that is rays converging to a point behind the mirror are reflected to a point on a screen.

22. A virtual image cannot be caught on a screen. Then how do we see it?

Ans. The image is virtual when reflected or refracted rays divergent, these are converged on to the retina by convex lens of eye, as the virtual image serves as the object.

23. Define critical angle for total internal reflection. Obtain an expression for refractive index of the medium in terms of critical angle.

24. The image of a small bulb fixed on the wall of a room is to be obtained on the opposite wall 's' m away by means of a large convex lens. What is the maximum possible focal length of the lens required.

Ans. For fixed distance 's' between object and screen, for the lens equation to give real solution for $u = v = 2f$, 'f' should not be greater than $4f = s$.

$\therefore \qquad f = s/4$

25. The angle subtended at the eye by an object is equal to the angle subtended at the eye by the virtual image produced by a magnifying glass. In what sense then does magnifying glass produce angular magnification?

Ans. The absolute image size is bigger than object size, the magnifier helps in bringing the object closer to the eye and hence it has larger angular size than the same object at 25 cm, thus angular magnification is achieved.

26. Obtain relation between focal length and radius of curvature, of (i) concave mirror (ii) convex mirror using proper ray diagram.

27. Two independent light sources cannot act as coherent sources. Why?

28. How is a wave front different from a ray? Draw the geometrical shape of the wavefronts when.

(i) light diverges from a point source,

(ii) light emerges out of convex lens when a point source is placed at its focus.

29. What two main changes in diffraction pattern of single slit will you observe when the monochromatic source of light is replaced by a source of white light.

30. You are provided with four convex lenses of focal length 1cm, 3cm, 10 cm and 100 cm. Which two would you prefer for a microscope and which two for a telescope.

31. For a glass prism($\mu=\sqrt{3}$), the angle of minimum deviation is equal to the angle of the prism. Find the angle of the prism.

Ans. Hence $\delta m=A$; $\mu=\dfrac{\text{Sin }(A+\delta m)/2}{\text{Sin }A/2}$; $\sqrt{3}=\dfrac{\text{Sin }A}{\text{Sin }A/2}$

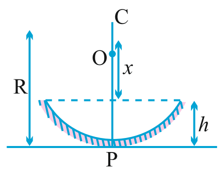
$$\sqrt{3}=\frac{2\text{Sin }A/2\ \text{Cos }A/2}{\text{Sin }A/2} \Rightarrow A=60^0$$

32. Using Huygens Principle draw ray diagram for the following :

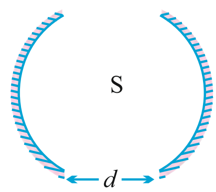
(i) Refraction of a plane wave front incident on a rarer medium

(ii) Refraction of a plane wave front incident on a denser medium.

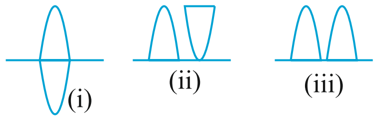
33. Water (refractive index μ) is poured into a concave mirror of radius of curvature 'R' up to a height h as shown in figure. What should be the value of x so that the image of object 'O' is formed on itself?



34. A point source S is placed midway between two concave mirrors having equal focal length f as shown in Figure. Find the value of d for which only one image is formed.

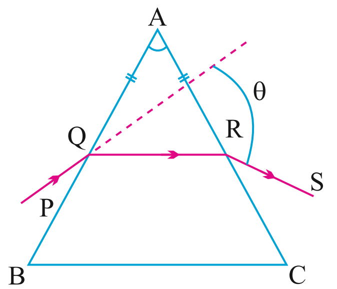


35. A thin double convex lens of focal length f is broken into two equal halves at the axis. The two halves are combined as shown in figure. What is the focal length of combination in (ii) and (iii).



36. How much water should be filled in a container 21 cm in height, so that it appears half filled when viewed from the top of the container. ($_{a}\mu_{\omega}$ = 4/3.)

37. A ray PQ incident on the refracting face BA is refracted in the prism BAC as shown in figure and emerges from the other refracting face AC as RS such that AQ = AR. If the angle, of prism A = 60° and μ of material of prism is $\sqrt{3}$ then find angle θ.



SHORT ANSWER QUESTIONS (3 Marks)

1. Name EM radiations used
(i) in the treatment of cancer.
(ii) For detecting flow in pipes carrying oil.
(iii) In sterilizing surgical instruments.

2. How would you experimentally show that EM waves are transverse in nature ?

3. List any three properties of EM waves.

4. Find the wavelength of electromagnetic waves of frequency 5×10^{19} Hz in free space. Give its two applications.

5. Using mirror formula show that virtual image produced by a convex mirror is always smaller in size and is located between the focus and the pole.

6. Obtain the formula for combined focal length of two thin lenses in contact, taking one divergent and the other convergent.

7. Derive Snell's law on the basis of Huygen's wave theory.

8. A microscope is focussed on a dot at the bottom of the beaker. Some oil is poured into the beaker to a height of 'b' cm and it is found that microscope has to raise through vertical distance of 'a' cm to bring the dot again into focus. Express refractive index of oil is terms of a and b.

9. Define total internal reflection. State its two conditions. Using a ray diagram show how does optical fibres transmit light.

10. A plane wave front is incident on (i) a prism (ii) A convex lens (iii) a concave mirror. Draw the emergent wavefront in each case.

11. Why is diffraction of sound waves more evident in daily experience than that of light waves ?

Ans. To occur diffraction condition required is " size of obstacle/operture must be of the order of wavelength of waves to be diffracted" since wavelength of light waves is of the order of 10^{-7} m, obstacles/apertures of this much of small size are hardly available.

While wavelength of sound waves vary from 15 m to 15 mm and obstacles / apertures of this size are commonly available.

There diffraction of sound waves is more evident in day to day life.

12. Derive Mirror formula for a concave mirror forming real Image.

13. Two narrow slits are illuminated by a single monochromatic sources.

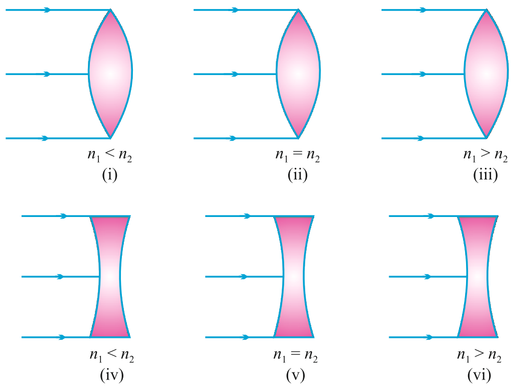
(a) Draw the intensity pattern and name the phenomenon

(b) One of the slits is now completely covered. Draw the intensity pattern so obtained.

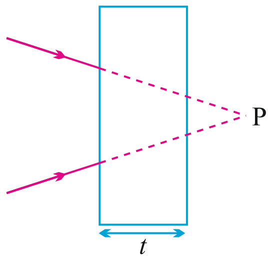
14. Explain (i) sparkling of diamond (ii) use of optical fibre in communication.

15. Using appropriate ray diagram obtain relation for refractive index of water in terms of real and apparent depth.

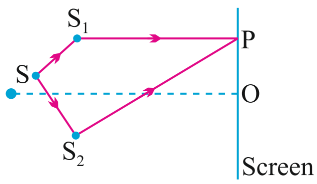
16. Complete the ray diagram in the following figure where, n_1 is refractive index of medium and n_2 is refractive index of material of lens.



17. A converging beam of light is intercepted by a slab of thickness t and refractive index μ, By what distance will the convergence point be shiffted? Illustrate the answer.



18. In double slit experiment SS_2 is greater than SS_1 by 0.25λ. Calculate the path difference between two interfering beam from S_1 and S_2 for minima and maxima on the point P as shown in figure.



LONG ANSWER QUESTIONS (5 MARKS)

1. With the help of ray diagram explain the phenomenon of total internal reflection. Obtain the relation between critical angle and refractive indices of two media. Draw ray diagram to show how right angled isosceles prism can be used to :
   (i) Deviate the ray through 180°.
   (ii) Deviate the ray through 90°.
   (iii) Invert the ray.
2. Draw a labelled ray diagram of a compound microscope and explain its working. Derive an expression for its magnifying power if final image is formed at least distance of distant vision.
3. Diagrammatically show the phenomenon of refraction through a prism. Define angle of deviation in this case. Hence for a small angle of incidence derive the relation $\delta = (\mu - 1)\,A$.
4. Explain the following :
   (a) Sometimes distant radio stations can be heard while nearby stations are not heard.
   (b) If one of the slits in Youngs Double Slit Experiment is covered, what change would occur in the intensity of light at the centre of the screen?

5. Define diffraction. Deduce an expression for fringe width of the central maximum of the diffraction pattern, produced by single slit illuminated with monochromatic light source.

6. What is meant by interference of light ? Define coherent sources of light. Describe briefly young's double slit experiment with the help of labelled ray diagram to demonstrate interference of light

7. Derive lens maker formula for a thin converging lens.

8. Derive lens formula $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$ for

(a) a convex lens, (b) a concave lens.

9. Describe an astronomical telescope and derive an expression for its magnifying power using a labelled ray diagram. When final image is formed at least distance of distinct vision.

10. Draw a graph to show the angle of deviation with the angle of incidence i for a monochromatic ray of light passing through a prism of refracting angle A. Deduce the relation

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

11. State the condition under which the phenomenon of diffraction of light takes place. Also draw the intensity pattern with angular position.

12. How will the interference pattern in Youngs double slit experiment change, when

(i) distance between the slits S_1 and S_2 is reduced and

(ii) the entire set up is immersed in water ?

Justify your answer in each case.

Ans. Fringe width $\beta = \frac{\lambda D}{d}$

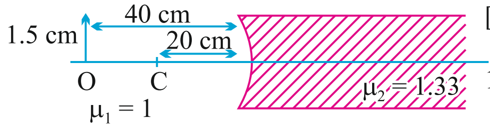
(i) If d decreases, fringe width $\beta \propto \frac{1}{d}$ increases

(ii) When apparatus is immersed in water, wavelength reduces to $\frac{\lambda}{\mu_\omega}$. Therefore, fringe width $\beta \propto \lambda$ decreases.

NUMERICALS

1. The refractive index of medium is 1.5. A beam of light of wavelength 6000 A° enters in the medium from air. Find wavelength and frequency of light in the medium.
2. An EM wave is travelling in vacuum. Amplitude of the electric field vector is 5×10^4 V/m. Calculate amplitude of magnetic field vector.
3. Suppose the electric field amplitude of an em wave is $E_0 = 120\ NC^{-1}$ and that its frequency is $v = 50.0$ MHz.
   (a) Determine B_0, ω, κ and λ,
   (b) Find expressions for E and B.
4. A radio can tune into any station of frequency band 7.5 MHz to 10 MHz. Find the corresponding wave length range.
5. The amplitude of the magnetic field vector of an electromagnetic wave travelling in vacuum is 2.4mT. Frequency of the wave is 16 MHz. Find :
   (i) Amplitude of electric field vector and
   (ii) Wavelength of the wave.
6. An EM wave travelling through a medium has electric field vector. $E_y = 4 \times 10^5 \cos (3.14 \times 10^8\ t - 1.57\ x)$ N/C. Here x is in m and t in s. Then find :
   (i) Wavelength
   (ii) Frequency
   (iii) Direction of propagation
   (iv) Speed of wave
   (v) Refractive index of medium
   (vi) Amplitude of magnetic field vector.
7. An object of length 2.5 cm is placed at a distance of 1.5 f from a concave mirror where f is the focal length of the mirror. The length of object is perpendicular to principal axis. Find the size of image. Is the image erect or inverted? [5 cm, Inverted]

8. Find the size of image formed in the situation shown in figure.



[5 cm, Inverted]

1.6 cm approx.

[1.2 cm, approx.]

9. A ray of light passes through an equilateral prism in such a manner that the angle of incidence is equal to angle of emergence and each of these angles is equal to 3/4 of angle of prism. Find angle of deviation.

[Ans. : 30°]

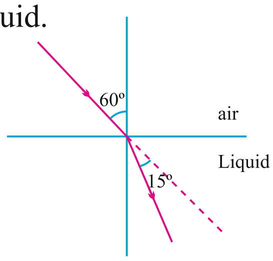
10. Two thin lenses are in contact and the focal length of the combination is 80 cm. If the focal length of one lens is 20 cm, then what would be the power of the other lens?

$$\text{Since } P = \frac{1}{f(\text{metre})} = \frac{100}{80} = 1.25D$$

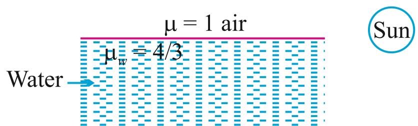
$$P = \frac{1}{f_1} = \frac{100}{20} = 5D$$

$$\because \quad P = P_1 + P_2 \quad \Rightarrow P_2 = P - P_1 = 1.25 - 5 = -3.75 \text{ D}$$

11. A light ray passes from air into a liquid as shown in figure. Find refractive index of liquid. $[{}^{air}\mu_{Liquid} = \sqrt{3/2}\,]$



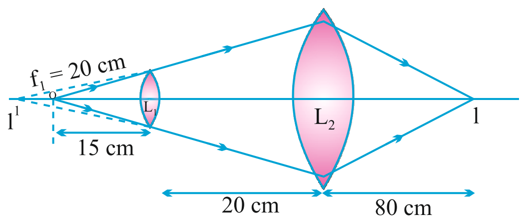
12. At what angle with the water surface does fish in figure see the setting sun ?



[C = Sin^{-1} (0.7518)]

[At critical angle, fish will see the sun.]

13. In the following diagram, find the focal length of lens L_2. [40 cm]



14. Three immiscible liquids of densities $d_1 > d_2 > d_3$ and refractive indices $\mu_1 > \mu_2 > \mu_3$ are put in a beaker. The height of each liquid is $\frac{h}{3}$. A dot is made at the bottom of the beaker. For near normal vision, find the apparent depth of the dot.

Ans. (Hint : the image formed by first medium act as an object for second medium) Let the apparent depth be O_1 for the object seen from $O_1 = \frac{\mu_2}{\mu_1} \cdot \frac{h}{3}$ image formed by medium 1, O acts as an object for medium 2. It is seen from M_3, the apparent depth is O_2.
Similarly, the image found by medium 2, O_2 act as an object for medium 3

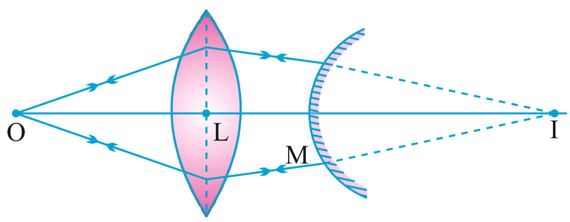
$$O_2 = \frac{\mu_3}{\mu_2}\left(\frac{h}{3}+O_1\right)$$

$$O_3 = \mu_3\left(\frac{h}{3}+O_2\right) \qquad \text{putting value of } O_2 \text{ and } O_1$$

$$O_3 = \frac{h}{3}\left(\frac{1}{\mu_1}+\frac{1}{\mu_2}+\frac{1}{\mu_3}\right)$$

15. A point object O is kept at a distance of 30 cm from a convex lens of power + 4D towards its left. It is observed that when a convex mirror is kept on right side at 50 cm from the lens, the image of object O formed by lens-mirror combination coincides with object itself. Calculate focal length of mirror.

Ans. Image formed by combination coincides with the object itself. It implies that I is the centre of curvature of convex mirror.



For lens

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

$$\frac{1}{25} = \frac{1}{v} + \frac{1}{30}$$

$$v = 150 \text{ cm}$$

$$MI = LI - LM = 150 - 50 = 100 \text{ cm}$$

$$f_m = \frac{MI}{2} = \frac{100}{2} = 50 \text{ cm}$$

16. Using the data given below, state which two of the given lenses will be preferred to construct a (i) telescope (ii) Microscope. Also indicate which is to be used as objective and as eyepiece in each case.

Lenses	Power (p)	Apetune (A)
L_1	6 D	1 cm
L_2	3 D	8 cm
L_3	10 D	1 cm

Ans. For telescope, lens L_2 is chosen as objective as it aperture is largest, L_3 is chosen as eyepiece as its focal length is smaller.

For microscope lens L_3 is chosen as objective because of its small focal length and lens L_1, serve as eye piece because its focal length is not larges.

17. Two thin converging lens of focal lengths 15 cm and 30 cm respectively are held in contact with each other. Calculate power and focal length of the combination.

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$= \frac{1}{15} + \frac{1}{30} = \frac{1}{10}$$

$$F = 10 \text{ cm}$$

$$P = 10D$$

18. An object is placed in front of a concave mirror of focal length 20 cm. The image is formed three times the size of the object. Calculate two possible distances of the object from the mirror.

Ans. $m = \pm 3$

$$m = \frac{-v}{u} = +3 \text{ for virtual image}$$

$$v = -3u$$

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

$$\frac{1}{-34}+\frac{1}{u} = -\frac{1}{20}$$

$$u = -\frac{40}{3}\text{cm}$$

$$m = \frac{-v}{u} = -3 \text{ for real image}$$

$$v = 3u$$

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

$$\frac{1}{3u}+\frac{1}{u} = -\frac{1}{20}$$

$$u = -\frac{80}{3}\text{cm.}$$

Question for Practice

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

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

3. How are electromagnetic waves produced by oscillating charges? What is the source of the energy associated with the em waves?

4. Name the radiation of the electromagnetic spectrum which is used for the following:

   (a) (i) Radar (ii) Eye surgery

   (b) To photograph internal parts of human body

   (c) For taking photographs of the sky during night and foggy conditions

   Give the frequency range in each case.

5. In young's double slit experiment using monochromatic light of wavelength λ, the intensity of light at a point on the screen where path difference is λ is "K" units. Find the intensity of light at a point where path difference is $\frac{\lambda}{3}$.

$$\text{Phase iff.} = \frac{2\pi}{\lambda}\times\frac{\lambda}{3}=\frac{2\pi}{3}=120°$$

and $$I = I_0 \cos^2 \frac{\phi}{2} = \frac{K}{4}$$

$$\left[\text{Hint} \quad I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi\right]$$

6. In young's double slit experiment, a light of wavelength 630 nm produces an interference pattern where bright fringes are separated by 8.1 mm. Another light produces the interference pattern. Where the bright fringes are separated by 72 mm. Calculate the wavelength of second light.

$$\left[\text{Hint} \quad \beta = \frac{\lambda D}{d}\right]$$

Ans. 560 nm

7. A beam of light consisting of two wavelength 800 nm and 600 nm is used to obtain the interference pattern in young's double slit experiment on a screen placed 1.4 m away. If the separation between two slits in 0.28 mm. Calculate the least distance from the central bright maximum, where the bright fringes of two wavelengths coincide.

Ans. $$x = n\lambda_1 \frac{D}{d} = (n+1)\lambda_2 \frac{D}{d}$$

$\therefore$ $$n \times 800 = (n+1)\lambda_2 \frac{D}{d}$$

$\therefore$ $$n = 3$$

$\therefore$ $$x = n\lambda_1 \frac{D}{d} = 3 \times 800 \times \frac{10^{-9} \times 1.4}{0.28 \times 10^{-3}} = 12 \text{ mm}$$

Numericals

1. The focal lengths of objective and eye peace of a microscope are 1.25 cm and 5 cm respectively find the position of the object relative to the objective in order to obtain an angular magnification of 30 in normal adjustment.

Ans. In normal adjustment

$$m_e = \frac{d}{f_e} = \frac{25}{5} = 5$$

$$m = m_0\, m_e$$

$\therefore$ $$m_0 = \frac{m}{m_e} = \frac{30}{5} = 6$$

and $$m_0 = \frac{V_0}{u_0} = -6$$

$\therefore$ $$V_0 = -6u_0$$

$\therefore$ $$\frac{1}{v_0} - \frac{1}{u_0} = \frac{1}{f_0}$$

$$\frac{1}{-6u_0} - \frac{1}{u_0} = \frac{1}{f_0}$$

here $$f_0 = 1.25 \text{ cm}$$

$u_0 = -1.46$ cm

2. A small telescope has an objective lens of focal length 150 cm and an eye piece of focal length 5 cm. If his telescope is used to view a 100 m high tower 3 km away find the height of the final image when it find the height of the final image when it is formed 25 cm away from the eye pieces.

Ans. $$\tan\alpha = \frac{100}{3000} = \frac{1}{30} \text{ radian}$$

again $$\tan\alpha = \frac{h}{f_0}$$

$\therefore \qquad \frac{1}{30} = \frac{h}{150}$

$h = 5$ cm

h height of image of tower

$\therefore \qquad m_e = \left(1 + \frac{\alpha}{f_e}\right) = \left(1 + \frac{25}{5}\right) = 6$

and $\qquad m_e = \frac{h'}{h}$

$\therefore \qquad h' = 5 \times 6 = 30$ cm

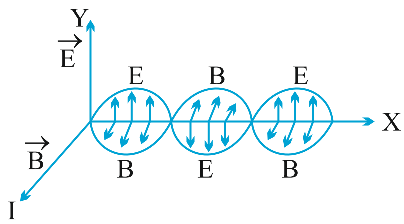
h' height of final image.

ANSWER OF 2 MARKS QUESTIONS

1. UV ray – In water purifier.

γ ray – In treatment of cancer

2.



3. An accelerated charge produces oscillating electric field in space, which produces an oscillating magnetic field, which in turn, is a source of oscillating electric field and so on. The oscillating electric & magnetic fields produces each other & give rise to e.m. waves.

4. In vacuum $\qquad C = \frac{E_0}{B_0}$

If electric field become $\frac{3}{4}E_0$, magnetic field will be $\frac{3}{4}B_0$.

5. (i) In green houses to keep plants warm.

(ii) In reading secret writings on ancient walls.

6. (i) In radio & tele communication systems.

(ii) In radio astronomy.

7. (i) In medical to diagnose fractures in bones.

(ii) In engineering for detecting cracks, flaws & holes in metal parts of a machine.

8.
$$\mu_E = \frac{1}{2}\varepsilon_0 E^2 \quad \& \quad u_B = \frac{1}{2}\frac{B^2}{\mu_0}$$

$$\mu_E = \frac{1}{2}\varepsilon_0 E^2 = \frac{1}{2}\varepsilon_0 (CB)^2 \qquad \text{As } c = \frac{E}{B}$$

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

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

$$= \mu_B$$

10. For concave mirror

$$f < 0 \quad \text{and} \quad u < 0$$
$$f < u < 0$$
$$\frac{1}{f} > \frac{1}{u} \quad \text{or} \quad \frac{1}{f} - \frac{1}{u} > 0$$
$$\text{or} \quad \frac{1}{v} > 0$$

Virtual image is formed.

Also
$$\frac{1}{v} < \frac{1}{|u|} \quad \text{or} \quad v > |u|$$

$$m = \frac{v}{|u|} > 1$$

magnified image.

11. $\theta = \sin^{-1}(8/9)$

13. $\sin^{-1}(3/4)$

16. 4 m pole

17. Minimum path difference is zero (when p is at infinity).

Maximum path difference = d.

29. A wavefront is a surface obtained by joining all points vibrating in the same phase.

A ray is a line drawn perpendicular to the wavefront in the direction of propagation of light.

(i) Spherical

(ii) Plane

30. (i) In each diffraction order, the diffracted image of the slit gets dispersed into component colours of white light. As fringe width α λ, $\therefore$ red fringe with higher wavelength is wider than violet fringe with smaller wavelength.

(ii) In higher order spectra, the dispersion is more and it cause overlapping of different colours.

31. f_0 = 1 cm and f_e = 3 cm for Microscope and

f_0 = 100 cm and f_e = 1 cm for a Telescope

33. N.C.E.R.T. Fig. 10.5; Fig. 10.4.

34. Distance of object from p should be equal to radius of curvature.

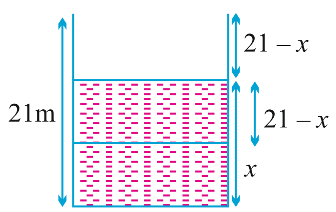
$$R = \mu x + h \Rightarrow \quad x = \frac{R - h}{\mu}$$

35. Distance between mirror will be $2f$ or $4f$.

36. (i) Focal length of combination is infinite,

(ii) $f/2$

37.



$$\frac{\text{Real depth}}{\text{Apparent depth}} = \mu$$

$$\frac{x}{21-x} = \frac{4}{3} \quad \Rightarrow \quad x = 12 \text{ cm}$$

38. This is a case of min. deviation $\theta = 60°$.

ANSWERS OF 3 MARKS QUESTIONS

17. $x = \left(1-\frac{1}{\mu}\right)t$

18. Path difference :

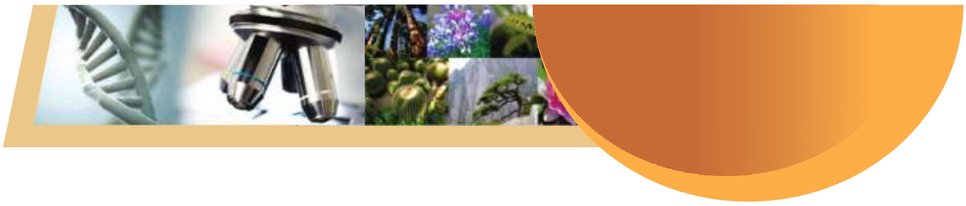
$$(SS_2 + S_2P) - (SS_1 + S_1P) = (SS_2 - SS_1) + (SS_2P - S_1P)$$
$$= (0.25\lambda + S_2P - S_1P)$$

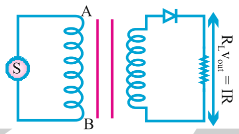
For maxima, path difference = $n\lambda$

So, $S_2P - S_1P = n\lambda - 0.25\lambda = (n - 0.25)\lambda$

For minima, path difference = $(2n+1)\frac{\lambda}{2}$

So, $S_2P - S_1P = (2n + 0.5)\ \lambda/2$.





Unit VII

Dual Nature of Matter
And Radiation

Unit VII

DUAL NATURE OF MATTER AND RADIATION

KEY POINTS

- Light consists of individual photons whose energies are proportional to their frequencies.
- A photon is a quantum of electromagnetic energy :

  Energy of photon

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

  Momentum of a photon

  $$= \frac{h\nu}{c} = \frac{h}{\lambda}$$

  Dynamic mass of photon

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

  Rest mass of a photon is zero.
- **Photoelectric effect :** Photon of incident light energy interacts with a single electron and if energy of photon is equal to or greater than work function, the electron is emitted.
- Max. kinetic energy of emitted electron $= h(\nu - \nu_0)$ Here ν_0 is the frequency below which no photoelectron is emitted and is called threshold frequency.
- If 'V' is the stopping potential of photoclectron emission, then max. kinetic energy of photo electron $E_K = qV$

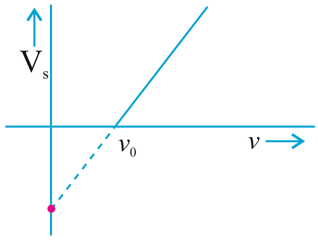
- Wavelength associated with the charge particle accelerated through a potential of V. volt.

$$l = \frac{h}{\sqrt{2mqV}}$$

- Wavelength associated with electron accelerated through a potential difference

$$l_e = \frac{12.27}{\sqrt{V}} \text{Å}$$

- Stopping potential versus frequency graph



$v_0 \rightarrow$ thershold frequency

scope of the curve gives $\frac{h}{e}$

The intercept on V axis gives $\frac{\phi}{e}$ i.e. $\frac{\text{Work function}}{e}$

- A moving body behaves in a certain way as though it has a wave nature having wavelength,

$$\lambda = \frac{h}{mv} = \frac{h}{p} = \frac{h}{\sqrt{2m\,E_k}}$$

where E_K is kinetic energy of movign particle

- Einestein's Photoelectric equation

$$\frac{1}{2}mv_{max}^2 = h\nu - h\nu_0$$

or $$eV_0 = h\nu - h\nu_0$$

Unit VIII
ATOMS AND NUCLEI

KEY POINTS

- Gieger-Marsden α-scattering experiment established the existence of nucleus in an atom.

  Bohr's atomic model

  (i) Electrons revolve round the nucleus in certain fixed orbits called stationary orbits.

  (ii) In stationary orbits, the angular momentum of electron is integral multiple of $h/2\pi$.

  (iii) While revolving in stationary orbits, electrons do not radiate energy. The energy is emitted (or absorbed) when electrons jump from higher to lower energy orbits, (or lower to higher energy orbits). The frequency of the emitted radiation is given by $hv = E_f - E_i$. An atom can absorb radiations of only those frequencies that it is capable of emitting.
- As a result of the quantisation condition of angular momentum, the electron orbits the nucleus in circular paths of specific radii. For a hydrogen atom it is given by

$$r_n = \left(\frac{n^2}{m}\right)\left(\frac{h}{2\pi}\right)^2 \frac{4\pi\varepsilon_0}{e^2} = \frac{n^2h^2\varepsilon_0}{\pi me^2}$$

$$\Rightarrow \qquad r_n \propto n^2$$

  The total energy is also quantised : $E_n = \dfrac{-me^4}{8n^2\varepsilon_0^2h^2} = -\,13.6\text{eV}/n^2$

  The $n = 1$ state is called the ground state.

  In hydrogen atom, the ground state energy is – 13.6 eV.
- de Broglie's hypothesis that electron have a wavelength $\lambda = h/mv$ gave an explanation for the Bohr's quantised orbits.
- Neutrons and protons are bound in nucleus by short range strong nuclear force. Nuclear force does not distinguish between nucleons.
- The nuclear mass 'M' is always less than the total mass of its constituents. The difference in mass of a nucleus and its constituents is called the **mass defect.**

$$\Delta M = [Zm_p + (A - Z)m_n] - M$$

and $$\Delta E_b = (\Delta M)c^2$$

The energy ΔE_b represents the binding energy of the nucleus.

For the mass number ranging from A = 30 to 170 the binding energy per nucleon is nearly constant at about 8MeV per nucleon.

QUESTIONS

VERY SHORT ANSWER QUESTIONS (1 Mark)

1. The photoelectric effect can be explained on the basis of

   (a) Wave theory (b) Electromagnetic theory

   (c) Quantum theory (d) Corpuscular theory

2. The wavelength of matter waves is independent of

   (a) Mass (b) Velocity

   (c) Momentum (d) Charge

3. If E_1, E_2, E_3 and E_4 are the respective kinetic energies of electron, deutron, proton and neutron having same de-Broglie wavelength, select the correct order in which those values would incrase:

   (a) E_1, E_3, E_4, E_2 (b) E_2, E_4, E_1, E_3

   (c) E_2, E_4, E_3, E_1 (d) E_3, E_1, E_2, E_4

4. Light of frequency $2.5v_0$ is incident on a metal surface of threshold frequency $2v_0$. If its frequency is halved and intensity is made doubled find the new value of photoelectric current.

   (a) 4 unit (b) 2.5. unit

   (c) zero (d) 1.05 unit

5. What is the momentum of photon of energy 3MeV in kg ms^{-1}?

   (a) 10^{12} kg ms^{-1} (b) 1.6×10^{-21} kg ms^{-1}

   (c) 3×10^{8} kg ms^{-1} (d) 1.6×10^{-19} kg ms^{-1}

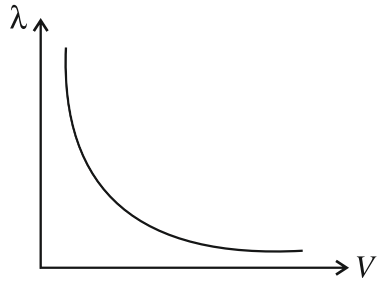
6. What is the momentum of an electron beam of wavelength 4Å?

   ($h = 6.62 \times 10^{-34}$Js)

   (a) 1.65×10^{-24} kg ms^{-1} (b) 3×10^{5} kg ms^{-1}

   (c) 9.1×10^{-30} kg ms^{-1} (d) 3.9×10^{-24} kg ms^{-1}

7. The variation of the de-Broglie wavelength (λ) with the potential (V) through which an electron is accelerated from rest is shown in graph below



Choose the correct option:

(a) $\lambda \alpha V$ (b) $\lambda \alpha \sqrt{V}$

(c) $\lambda \alpha \frac{1}{\sqrt{V}}$ (d) $\lambda \alpha v^2$

8. A proton and electron have same velocity. Which one option is correct for deBroglie wavelength of Proton (λ_p) and electron (λ_e)?

(a) $\lambda_p = \lambda_e \neq 0$ (b) $\lambda_p < \lambda_e$

(c) $\lambda_p > \lambda_e$ (d) $\lambda_p = \lambda_e = 0$

9. The threshold frequency of a certain metal is 3.3×10^{14} Hz. If light of frequency 8.2×10^{14} Hz is incidenet on the metal, predict the cut off voltage for photoelectric emission. ($h = 6.62 \times 10^{-34}$ Js)

(a) 202.74 V (b) 305.12V

(c) 531.5 V (d) 200 V

10. What is the momentum of an electron with K.E of 120 eV. (Given $h = 6.63 \times 10^{-34}$ Js, Me $= 9.1 \times 10^{-31}$ Kg; 1 eV $= 1.6 \times 10^{-19}$ J)

(a) 2×10^{-19} kg ms^{-1} (b) 5.88×10^{-24} kg ms^{-1}

(c) 9×10^{9} kg ms^{-1} (d) 5×10^{19} kg ms^{-1}

Answer

Q.	1	2	3	4	5	6	7	8	9	10
A.	(c)	(d)	(c)	(c)	(b)	(a)	(c)	(b)	(a)	(b)

QUESTIONS

Chapter-12 and 13 Atom & Nuclei
MCQ

1. α-particles are incident on a thin gold foil. For what angle of deviation will the number of α-particle be minimum?

   (a) $0°$ (b) $90°$

   (c) $120°$ (d) $180°$

2. Number of electrons and neutrons in $^{236}_{92}U$ atom will be-

   (a) electrons = 92, Neutrons = 144 (b) electrons = 144, Neutrons = 92

   (c) electrons = 236, Neutrons = 92 (d) electrons = 92, Neutrons = 236

3. After losing two electrons, to which particle does a helium atom get transformed into?

   (a) α-particle (b) β-particle

   (c) γ-particle (d) photon

4. The energy released in fusion reaction

   $^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{2}He + n$

   Where B.E of $^{2}_{1}H = 2.23$ MeV and $^{3}_{2}He = 7.73$ MeV

   (a) 4.5 MeV (b) 5.9 MeV

   (c) 6.2 MeV (d) 3.27 MeV

5. Two nuclei of mass numbers 1 and 27 have their radii ratio as—

   (a) 2 : 5 (b) 5 : 2

   (c) 1 : 5 (d) 1 : 3

6. The light energy emitted by a star is due to—

   (a) Joining of nuclei

   (b) Burning of nuclei

   (c) Breaking of nuclei

   (d) Reflection of solar light

7. Energy of an electron in nth orbit of hydrogen atom is—

(a) $\frac{-13.6}{n^2}$ eV (b) $\frac{n^2}{13.6}$ eV

(c) $\frac{-n^2}{13.6}$ eV (d) $\frac{-13.6}{n}$ eV

8. According to de-Broglie explanation of Bohr's second postulate of quantisation, the standing particle wave n a circular orbit for $n = 4$ is given by—

(a) $\frac{2\pi}{\lambda} = 2r_n$ $2\pi r_n = 3\lambda$

(c) $2\pi r_n = 4\lambda$ $\frac{\lambda}{2\pi} = 2r_n$

9. Angular momentum of an electron in the second orbit of an atom is—

(a) 5×10^{-31} Js 2.1×10^{-34} Js

(c) 5×10^{-9} Js 2.1×10^{-9} Js

10. According to the Bohr's atomic theory, what will be the energy of hydrogen atom for principal quantum number ∞?

(a) Infinite (b) –13.6 eV

(c) 13.6eV (d) Zero

11. The wavelength limits of Lymas, Balmer and Paschen series are λ_L, λ_B and λ_P respectively. Wavelengths in increasing order can be written as—

(a) $\lambda_P < \lambda_B < \lambda_L$ $\lambda_P > \lambda_B > \lambda_L$

(c) $\lambda_P = \lambda_B = \lambda_L$ $\lambda_L > \lambda_B > \lambda_P$

12. Two nuclei have mass numbers in the ratio of 1 : 2. What is the ratio of their deusities?

(a) 1 : 2 (b) 2 : 1

(c) 1 : 1 (d) 3 : 1

13. One milligram of matter is converted into energy, the energy released will be

(a) 9×10^{10} J (b) 7×10^{9} J

(c) 10 J (d) 900 J

14. If in a nuclear fusion process, the masses of the fusion nuclei are m_1 and m_2 and mass of the resultant nucleus is m_3, then

(a) $m_3 = (m_1 - m_2)$ (b) $m_3 < (m_1 + m_2)$

(c) $m_3 = m_1 + m_2$ (d) $m_3 = m_2 - m_1$

15. The biuding energy of deuteron is 2.2. MeV and that of ${}^4_2He$ is 28MeV. If two deuteron are fused to form one ${}^4_2He$ then energy released is —

(a) 30.5 MeV (b) 23.6 MeV

(c) 31.5 MeV (d) 19.5 MeV

Answers

1. (d)
2. (a)
3. (a)
4. (d)
5. (d)
6. (a)
7. (a)
8. (c)
9. (b)
10. (d)
11. (d)
12. (c)
13. (a)
14. (b)
15. (b)

Assertion - Reason Questions

Dual Nature

For question 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 correct explanation of A

b) Both A and R are true but R is not correct explanation of A

c) A is true but R is false

d) A is false and R is also false

1. Assertion : Photoelectric effect demonstrate the wave nature of light.

   Reason : The number of photoelectrons is proportional to the frequency of light.

2. Assertion : The energy of X-ray photon is greater than that of visible light photon.

   Reason : X-ray photon in vacuum travels faster than light photon.

3. Assertion : A partial of mass mat rest decays into two particles of masses m_1 and m_2 having non-zero velocities, will have ratio of de-Broglie wavelengths unity.

   Reason : Here we cannot apply conservation of linear momentum.

4. Assertion : Light of frequency 1.5 times the threshold frequency is incident on a photo sensitive material of the frequency is halved and intensity is doubled, the photo electric current remains unchanged.

   Reason : The photo electric current varies diversity with the intensity of light and frequency of light.

5. Assertion : A photon has no rest mass, yet it carries definite momentum.

   Reason : Momentum of photon is due to its energy and hence its equivalent mass.

Answers :

1. a) 2. c) 3. c) 4. d) 5. a)

Assertion - Reason Question (Atom & Nuclei)

1 Assertion : Balmer series lie in the visible region of electro magnetic spectrum

Reason : Wavelength of photon emitted when electron jumps from higher energy state to lower energy

Stable is given $\frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{n^2}\right]$

n=3 to 00

2. Assertion : Total energy of an electron in hydrogen atom is negative.

   Reason : Electron is bounded to the nucleus.
3. Assertion : In a radioactive decay an electron is emitted by the nucleus.

   Reason : Electron are present inside the nucleus.
4. Assertion : Force acting between proton-proton (f_{pp}) is less than fine acting between proton-proton (f_{pn}) inside a nucleus.

   Reason : Protons being positively charged, repel each other by coulombian free.
5. Assertion : Unlike gravitational and electro-static forces, nuclear force has limited range.

   Reason : Nuclear forces do not obey inverse square law.

Case Study Questions

DUAL NATURE OF MATTER & RADIATION

I. Photocell is usually a vacuum tube having two electrodes. One is a cathode made of a photo sensitive material, which units electrons when exposed to light of sufficient frequency and the other is an anode. Which is maintained at a positive potential with respect to cathode. When light of suitable frequency strikes on cathode, electrons are inutted from cathode and are attracted to the anode and a current flows. This current can be used to open a door, ring a bell

Attempt any 4 sub-parts from each question.

Each question carries one mark.

1. Photocell is based on the phenomenon of

a)	Compton effect	b)	Photo electric effect
c)	Magnetic effect of current	d)	Photo electric effect

2. If the wavelength of evident radiation is greater than the threshold wave length for a metal surface then

   a) Kinetic energy of photoelectron will be higher

   b) Photoelectric current will be higher

   c) Photoelectric effect will not take place

   d) None of the above

3. A photocell units electrons when exposed to the light of the frequency of incident light is increased keeping intensity constant then

   a) Magnitude of cut-off voltage will increase

   b) Photo electric current will decrease

   c) No photoelectron will unit

   d) Photoelectrons will unit but their kinetic energy will be zero

4. Photoelectric effect is used in

a)	Cyclotron	b)	Moving coil galvanometer
c)	Van de Graaff Generator	d)	Photocell

5. Light radiations of suitable frequency incident on a photosensitive surface. How will the kinetic energy of photoelectrons vary if the intensity of incident radiations increased.

a)	Remains same	b)	Increase
c)	Decrease	d)	None of the above

Answers :

1. (b) 2. (c) 3. (a) 4. (d) 5. (a)

II **de Broglie Hyper thesis**

de Broglie in 1924 proposed that matter should also exhibit dual behaviour like properties. It means that just the photon has momentum as well as wavelength, de-Broglie gave the following relation between wavelength and momentum (p) of a material particles.

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

When in is mars of the particles and v its velocity.

Electron micros cope is mad on wave like behaviour of electron just as ordinary microscope utilize the wave nature of light. An electron microscope is a powerful tool in modern scientific research because it achieves a magnification of about 15 million times that of ordinary optical microscope.

Attempt any 4 sub parts from each question.

Each question carries 1 mark.

1. An electron, have same moments, which one has greater de-Bringlie wavelength?

   a) Electron b) Proton

   c) X-particle d) All have same de-Bringlie wavelength

2. An electron, a proton a electron and an alpha particle are moving with speed. which one has greater de-Bronglie wavelength?

   a) Electron b) Proton

   c) Decetron d) Alpha particle

3. de-Broglie waves are :

   a) Light waves b) Micro waves

   c) Waves d) All of the above

4. The magnification produced by electron microscope is

   a) Greater than ordinary optical microscope

   b) Less than ordinary optical microscope

   c) Same as that of ordinary optical microscope

   d) none of the above

Answers :

1. (d) 2. (a) 3. (c) 4. (a) 5. (b)

III A spectral line is a dark or bright line in an otherwise uniform and continuos spectrum. The spectrum is obtained when emission or obsarbuon of light take place in a frequency range: In emission spectrum there are bright lines on a dark background. The spectrum emitted by atonic hydrogen has various spectral line. These are certain sets of spectral lives in the spectrum of hydrogen atom. Each such set is called spectral series. The wave length of radiation emitted during a transition from higher energy level to lower energy level is given by-

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

When R=1.101 x 10^7 m^{-1}, n_f & ni are lower & higher energy state respectively.

1. Which of the following transition corresponds to Paschen series-

a) $n_f = 1$, ni=2 to 00

b) $n_f=2$, ni=3 to 00

c) $n_f=3$, ni=4 to 00

d) $n_f=4$, ni=5 to 00

2. Which of the following spectral series lies in visible region-

a) Lyman series

b) Belmer series

c) Paschan series

d) pfimd series

3. The shortest wave length of lyman series is

a) 10.20 Å

b) 917 Å

c) 410 Å

d) 659 Å

4. The wavelength of H_2 line is -

   a) 1500 Å

   b) 8200 Å

   c) 6566 Å

   d) 4861 Å

5. Which of the following series lies in UV region-

   a) Belmer series

   b) Paschen series

   c) Branett series

   d) Lyman series

Nuclear Energy

IV. A Heavy nucleus breaks into comparatively lighter nuclei which are more stable compared to the original heavy nucleus. When a heavy nucleus like uranium is bombarded by slow moving neutrons, it splits into two parts releasing large amount of energy. The typical fission reacion of U-235 is, ${}_{92}U^{235} + {}_{0}n^{1} \longrightarrow {}_{56}Ba^{141} + {}_{36}Kr^{92} + {}_{30}n^{1} + 200MeV$ the fission of U-235 releases 200 MeV energy.

1. If 200 MeV energy is released in the fission of single nucleus of ${}^{235}U_{92}$. The fissions which are required to produce a power of 1 KW is
(a) $3.125\text{x}10^{13}$ (b) $1.52\text{x}10^{6}$ (c) $3.125\text{x}10^{12}$ (d) $3.125\text{x}10^{14}$

2. The release in energy in Nuclear fission is consistent with the fact that uranium has
(a) More mass per nucleon than either of two fragments
(b) More mass per nucleon as two fragments
(c) exactly the same mass per nucleon as the two fragments
(d) less mass per nucleon than either of two fragments.

3. when ${}^{235}U_{92}$ undergoes fission about 0.1% of the original mass is converted into energy.

The energy released when 1 kg uranium undergoes fission is

(a) $9x10^{11}J$ (b) $9x10^{13}J$

c) $9x10^{15}J$ (d) $9x10^{18}J$

4. An uncontrolled nuclear chain reaction form the basis of

(a) Bio-gas Plant (b) Hydro electric power station

(c) Nuclear reactor (d) atom bomb

5. Fission of a nucleus is achieved by bombarding it with

(a) proton (b) neutron (c) electron (d) X-ray

Answers:

Case Study Questions (III)

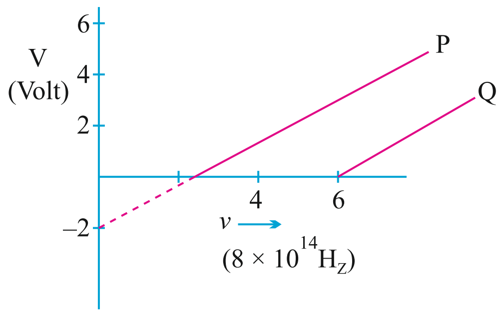
1. a) 2. a) 3. c) 4. a) 5. a)

Case Study question : (IV)

Ans. (1) (a) (2) (d) (3) (b) (4) (c) (5) (b)

SHORT ANSWER QUESTIONS (2 Marks)

1. Write one similarity and one difference between matter wave and an electromagnetic wave.
2. Does a photon have a de-Broglie wavelength? Explain.
3. A photon and an electron have energy 200 eV each. Which one of these has greater de-Broglie wavelength?
4. The work function of the following metal is given Na = 2.75 eV, K = 2.3 eV, Mo = 4.14 eV, Ni = 5.15 eV which of these metal will not give a photoelectric emission for radiation of wave length 3300 A° from a laser source placed at 1m away from the metal. What happens if the laser is brought nearer and placed 50 cm away.
5. Represent graphically Variation of the de-Broglie wavelength with linear momentum of a particle.
6. In a photoelectric effect experiment, the graph between the stopping potential V and frequency of the incident radiation on two different metals P and Q are shown in Fig. :



   (i) Which of the two metals has greater value of work function?

   (ii) Find maximum K.E. of electron emitted by light of frequency $\nu = 8 \times 10^{14}$ Hz for metal P.

7. Do all the photons have same dynamic mass? If not, Why?
8. Why photoelectrons ejected from a metal surface have different kinetic energies although the frequency of incident photons are same?

9. Find the ratio of de-Broglie wavelengths associated with two electrons 'A' and 'B' which are accelerated through 8V and 64 volts respectively.

10. Explain the terms stopping potential and threshold frequency.

11. How does the maximum kinetic energy of emitted electrons vary with the increase in work function of metals?

12. Define distance of the closest approach. An α-particle of kinetic energy 'K' is bombarded on a thin gold foil. The distance of the closest approach is 'r'. What will be the distance of closest approach for an α-particle of double the kinetic energy?

13. An particle and a proton are accelerated by same potential. Find ratio of their de Broglie wavelengths. **Ans.** $[1:2\sqrt{2}]$

14. Draw a diagram to show the variation of binding energy per nucleon with mass number for different nuclei. State with reason why light nuclei usually undergo nuclear fusion.

15. What is the main difference between fission reaction and fusion reaction ? Give one example of each.

16. If the total number of neutrons and protons in a nuclear reaction is conserved how then is the energy absorbed or evolved in the reaction?

17. In the ground state of hydrogen atom orbital radius is 5.3×10^{-11} m. The atom is excited such that atomic radius becomes 21.2×10^{-11} m. What is the principal quantum number of the excited state of atom?

18. What are nuclear forces? Give their important properties.

19. Why is the density of the nucleus more than that of atom?

20. The atom ${}_8O^{16}$ has 8 protons, 8 neutrons and 8 electrons while atom ${}_4Be^8$ has 4 proton, 4 neutrons and 4 electrons, yet the ratio of their atomic masses is not exactly 2. Why?

21. What is the effect on neutron to proton ratio in a nucleus when β^- particle is emitted ? Explain your answer with the help of a suitable nuclear reaction.

22. Why must heavy stable nucleus contain more neutrons than protons?

23. Distinguish between isotopes, isobars and isotones with suitable examples.
24. What is a nuclear fusion reaction? Why is nuclear fusion difficult to carry out for peaceful purpose?
25. Write two characteristic features of nuclear forces which distinguish them from coulomb force.
26. Half life of certain radioactive nuclei is 3 days and its activity is 8 times the 'safe limit'. After how much time will the activity of the radioactive sample reach the 'safe limit'?
27. Derive $mvr = \frac{nh}{2\pi}$ using de-Broglie equation.
28. Draw graph of number of scattered particles to scattering angle in Ratherford's experiment.
29. If the energy of a photon is 25 eV and work function of the material is 7eV, find the value of slopping potential.
30. What is the shortest wavelength present in the (i) Paschen series (ii) Balmer series of spectral lines?
Ans. (i) 820nm, (ii) 365 nm
31. The radius of the inner most electron orbit of a hydrogen atom 0.53 Å. What are the radii of the $n = 2$ and $n = 3$ orbits. [**Hint:** $r = n^2r_0$)
32. The ground state energy of hydrogen atom is –13.6 eV. What are the kinetic and potential energies of the electron in this state?
[**Hint :** K.E = – (T.E), P.E. = 2T.E]
33. Why is the wave nature of matter not more apparent to our daily observations ?
34. From the relation $R = R_0 A^{1/3}$ where R_0 is a constant and A is the mass number of a nucleus, show that nuclear matter density is nearly constant.

Ans. Nuclear matter density $= \frac{\text{Mass of nucleus}}{\text{Volume of nucleus}}$

$$= \frac{mA}{\frac{4}{3}\pi R^3} = \frac{mA}{\frac{4}{3}\pi R_0^3 A}$$

$$= \frac{m}{\frac{4}{3}\pi R_0^3} = 2.3 \times 10^{17} \text{ kg / m}^3$$

$$= \text{Constant}$$

35. Find the energy equivalent of one atomic mass unit in joules and then in MeV.

Ans. E = Δmc^2 Δm = 1.6605 × 10^{-27} kg

$$= 1.6605 \times 10^{-27} \times (3 \times 10^8)^2$$

$$= 1.4924 \times 10^{-4} \text{J}$$

$$= \frac{1.4924 \times 10^{-10}}{1.6 \times 10^{-19}} eV$$

$$= 0.9315 \times 10^9 \text{ eV}$$

$$= 931.5 \text{ MeV}$$

36. Write four properties of nuclear force.

SHORT ANSWER QUESTIONS (3 Marks)

1. Explain the working of a photocell? Give its two uses.

2. Find the de-Broglie wavelength associated with an electron accelerated through a potential difference V.

3. What is Einstein's explanation of photo electric effect? Explain the laws of photo electric emission on the basis of quantum nature of light.

4. Light of intensity I and frequency v is incident on a photosensitive surface and causes photoelectric emission. Justify with the help of graph, the effect on photoelectric current when

(i) the intensity of light is gradually increased

(ii) the frequency of incident radiation is increased

(iii) the anode potential is increased

In each case, all other factors remain the same.

5. Write Einstein's photoelectric equation. State Clearly the three salient features observed in photoelectric effect which can be explained on the basis of the above equation.

6. Explain the effect of increase of (i) frequency (ii) intensity of the incident radiation on photo electrons emitted by a metal.

7. X-rays of wave length λ fall on a photo sensitive surface emitting electrons. Assuming that the work function of the surface can be neglected, prove that the de-Broglie wavelength of electrons emitted will be $\sqrt{\frac{h\lambda}{2mc}}$.

Ans. $E = \frac{hc}{\lambda} = \frac{P^2}{2m} \therefore P = \sqrt{\frac{2mnc}{\lambda}}, \lambda_e = \frac{h}{P} = \sqrt{\frac{h\lambda}{2mc}}$

8. A particle of mass M at rest decays into two particles of masses m_1 and m_2 having velocities V_1 and V_2 respectively. Find the ratio of de-Broglie wavelengths of the two particles.

Ans. 1 : 1

9. Give one example of a nuclear reaction. Also define the Q-value of the reaction. What does Q > 0 signify?

10. Define atomic mass unit and electron volt. Derive relation between them.

11. Show that nuclear matter density is independent of A

12. what is mass defect of a nucleus ? Express it mathematically. How do your account for it ?

13. What is packing fraction ? Give its physical significance in relation to nuclear stability.

14. A nuclear bomb and a nuclear reactor work on the same principle. Explain why in one case explosion occurs and in the other energy is available at a steady rate.

15. Distinguish between nuclear fusion and fission. Give an example of each.

16. Explain the source of energy in the sun.

17. Obtain a relation for total energy of the electron in terms of orbital radius. Show that total energy is negative of K.E. and half of potential energy.

$$E = \frac{-e^2}{8\pi\varepsilon_0 r}$$

18. Draw energy level diagram for hydrogen atom and show the various line spectra originating due to transition between energy levels.

19. The total energy of an electron in the first excited state of the hydrogen atom is about – 3.4 eV. What is

(a) the kinetic energy,

(b) the potential energy of the electron?

(c) Which of the answers above would change if the choice of the zero of potential energy in changed to (i) + 0.5 eV (ii) – 0.5 eV.

Ans. (a) When P.E. is chosen to be zero at infinity E = – 3.4 eV, using E = – K.E., the K.E. = + 3.4 eV.

(b) Since P.E. = – 2E, PE = – 6.8 eV.

(c) If the zero of P.E. is chosen differently, K.E. does not change. The P.E. and T.E. of the state, however would alter if a different zero of the P.E. is chosen.

(i) When P.E. at ∞ is + 0.5 eV, P.E. of first excited state will be – 3.4 – 0.5 = – 3.9 eV.

(ii) When P.E. at ∞ is + 0.5 eV, P.E. of first excited state will be – 3.4 – (– 0.5) = – 2.9 eV.

20. What is unclear holocaust ?

21. Calculate the energy released in MeV in the deuterium-tritium fusion reaction:

$${}_1^2H + {}_1^3H \rightarrow {}_2^4He + n$$

using data

$m({}_1^2H) = 2.014102u$;

$m({}_1^3H) = 3.016049$ u;

$m({}_2^4He) = 4.002603$ u;

$m_n = 1.008665$ u,

$1u = 931.5$ MeV/c^2

LONG ANSWER QUESTIONS (5 Marks)

1. State Bohr's postulates. Using these postulates, derive an expression for total energy of an electron in the n^{th} orbit of an atom. What does negative of this energy signify?
2. Define binding energy of a nucleus. Draw a curve between mass number and average binding energy per nucleon. On the basis of this curve, explain fusion and fission reactions.
3. What do you mean by binding energy of a nucleus? Obtain an expression for binding energy. How binding energy per nucleon explains the stability of nucleus.
4. What is meant by nuclear fission and fusion. Draw Binding Energy Vs Mass Number curve and explain four important features of this curve.
5. Briefly explain Rutherford's experiment for scattering of α particle with the help of a diagram. Write the conclusions made and draw the model suggested.

NUMERICALS

1. Ultraviolet light of wavelength 350 nm and intensity 1 W/m^2 is directed at a potassium surface having work function 2.2eV.

(i) Find the maximum kinetic energy of the photoelectron.

(ii) If 0.5 percent of the incident photons produce photoelectric effect, how many photoelectrons per second are emitted from the potassium surface that has an area 1cm^2.

$$E_{Kmax} = 1.3 \text{ eV};\ n = 8.8\times10^{11}\,\frac{\text{photo electron}}{\text{second}} \text{ or } r = \frac{Nhv}{t} = nhv$$

2. A metal surface illuminated by 8.5 × 10^{14} Hz light emits electrons whose maximum energy is 0.52 eV the same surface is illuminated by 12.0 × 10^{14} Hz light emits elections whose maximum energy is 1.97eV. From these data find work function of the surface and value of Planck's constant. [Work Function = 3eV]

3. An electron and photon each have a wavelength of 0.2 nm. Calculate their momentum and energy.

(i) 3.3 × 10^{-24} kgm/s

(ii) 6.2 keV for photon

(iii) 38eV for electron

4. What is the (i) Speed (ii) Momentum (ii) de-Broglie wavelength of an electron having kinetic energy of 120eV?

Ans. (a) 6.5 × 10^6 m/s; (b) 5.92 × 10^{-24} kg m/s; (c) 0.112 nm.

5. If the frequency of incident light in photoelectric experiment is doubled then does the stopping potential become double or more than double, justify? (More than double)

Long Answer Question :

6. (A) Why wave theory of light could not explain the photoelectric effect? State two reasons. Draw graph between

(i) frequency v vs stopping potential V_0.

(ii) Intensity vs photoelectric current.

(iii) anode potential vs photoelectric current.

6.(B) A proton is accelerated through a potential difference V. Find the percentage increase or decrease in its de-Broglie wavelength if potential difference is increased by 21%.

Ans. (9.1%)

7. For what kinetic energy of a neutron will the associated de-Broglie wavelength be 5.6×10^{-10}m?

Ans.
$$\sqrt{2m_n \times \text{K.E.}} = \frac{h}{\lambda}$$

$$\Rightarrow \quad \text{K.E.} = \left(\frac{h}{\lambda}\right)^2 \frac{1}{2m_n}$$

$$= \left(\frac{6.625\times10^{-34}}{5.6\times10^{-10}}\right)^2 \frac{1}{2\times1.67\times10^{-27}}$$

$$= 3.35 \times 10^{-21}\text{J}$$

8. A nucleus of mass M initially at rest splits into two fragments of masses $\frac{M}{3}$ and $\frac{2M}{3}$. Find the ratio of de-Broglie wavelength of the fragments.

Ans. Following the law of conservation of momentum,

$$\frac{M}{3}v_1 + \frac{2M}{3}v_2 = 0$$

or
$$\left|\frac{M}{3}v_1\right| = \left|\frac{2M}{3}v_2\right|$$

$$\lambda = \frac{h}{mv} \Rightarrow \left|\frac{\lambda_1}{\lambda_2}\right| = \left|\frac{2\frac{M}{3}v_2}{\frac{M}{3}v_1}\right| = 1$$

9. An electron and a proton are possessing same amount of K.E., which of the two have greater de-Broglie, wavelength? Justify your answer.

Ans.
$$E_e = \frac{1}{2}m_e v_e^2$$

and
$$E_p = \frac{1}{2}m_p v_p^2$$

$$\Rightarrow \quad m_e v_e = \sqrt{2E_e m_e} \text{ and } m_p v_p = \sqrt{2E_p m_p}$$

But, $E_e = E_p \Rightarrow \frac{\lambda_e}{\lambda_p} = \sqrt{\frac{m_p}{m_e}} > 1$

$\therefore \quad \lambda_e > \lambda_p.$

10. The electron in a given Bohr orbit has a total energy of –1.51 eV. Calculate the wavelength of radiation emitted, when this electon makes a transition to the ground state.

Ans. 1028 A°

11. Calculate the radius of the third Bohr orbit of hydrogen atom and energy of electron in third Bohr orbit of hydrogen atom.

Ans. (–1.51 eV)

12. Calculate the longest and shortest wavelength in the Balmer series of Hydrogen atom. Rydberg constant = 1.0987×10^7 m^{-1}.

Ans. $\lambda_l = 6553$ A°, $\lambda_s = 3640$A°

13. What will be the distance of closest approach of a 5 MeV a-particle as it approaches a gold nucleus? (given Atomic no. of gold = 79)

Ans. 4.55×10^{-14}m

14. A 12.5 MeV alpha – particle approaching a gold nucleus is deflected 180°. What is the closest distance to which it approaches the nucleus?

Ans. 1.82×10^{-14}m

15. Determine the speed of the electron in $n = 3$ orbit of hydrogen atom.

Ans. $7.29 \times 10^5 ms^{-1}$

16. The three stable isotopes of neon: Ne^{20}, Ne^{21}, Ne^{22} have respective abundances of 90.51%, 0.27% and 9.22%. The atomic masses of the three isotopes are 19.99 amu, 20.99 amu and 21.99 amu respectively. Obtain the average atomic mass of neon.

Ans. 20.18 amu.

17. Obtain the binding energy of a nitrogen nucleus ($^{14}_{7}N$) from the following data: m_H = 1.00783 amu; m_n=11.00867 amu; M_N = 14.00307 amu, Give your answer in MeV

Ans. 104.7MeV

18. A given coin has a mass of 3.0 g . Calculate the nuclear energy that would be required to separate all the neutrons and protons from each other. For simplicity assume that the coin is entirely made of $^{63}_{29}Cu$ atoms (of mass 62.92960 amu). The masses of proton and neutron are 1.00783 amu and 1.00867 amu, respectively.

Ans. 1.582×10^{25} MeV

19. Binding energy of $_2He^4$ and $_3Li^7$ nuclei are 27.37 MeV and 39.4 MeV respectively. Which of the two nuclei is more stable? Why?

Ans. $_2He^4$ because its BE/nucleon is greater.

20. Find the binding energy and binding energy per nucleon of nucleus $_{83}B^{209}$.

Given : mass of proton = 1.0078254 u. mass of neutron = 1.008665 u.

Mass of $_{83}Bi^{209}$ = 208.980388u.

Ans. 1639.38 MeV and 7.84 MeV/Nucleon

21. Is the fission of iron ($_{26}Fe^{56}$) into ($_{13}Al^{28}$) as given below possible?

$_{26}Fe^{56} \rightarrow {}_{13}Al^{28} + {}_{13}Al^{28} + Q$

Given mass of $_{26}Fe^{56}$ = 55.934940 and $_{13}Al^{28}$ = 27.98191 U

Ans. Since Q value comes out negative, so this fission is not possible

22. Find the maximum energy that β-particle may have in the following decay :

$_8O^{19} \rightarrow {}_9F^{19} + {}_{-1}e^0 + \vec{v}$

Given

m ($_8O^{19}$) = 19.003576 a.m.u.

m ($_9F^{19}$) = 18.998403 a.m.u.

m ($_{-}e^0$) = 0.000549 a.m.u.

Ans. 4.3049 MeV

23. The value of wavelength in the lyman series is given as

$$\lambda = \frac{913.4 n_i^2}{n_i^2 - 1} \text{ Å}$$

Calculate the wavelength corresponding to transition from energy level 2, 3 and 4. Does wavelength decrease or increase ?

Ans.

$$\lambda_{21} = \frac{913.4 \times 2^2}{2^2 - 1} = 1218 \text{ Å}$$

$$\lambda_{31} = \frac{913.4 \times 3^2}{3^2 - 1} = 1028 \text{ Å}$$

$$\lambda_{41} = \frac{913.4 \times 4^2}{4^2 - 1} = 974.3 \text{ Å}$$

$\lambda_{41} < \lambda_{31} < \lambda_{21}$

Answer to 2 Marks Question

1. Similarity : Both follow wave equation (partial differential equation) dissimilarity : Matter waves

(a) cannot be radiated in empty space.

(b) are associated with the particles, not emitted by it

2. Yes, $\lambda = \dfrac{hc}{E}$

3. $\lambda = \dfrac{h}{p}$ for photon $P = \dfrac{E}{C}$ and $l = \dfrac{hc}{E}$ for electron $P = \sqrt{2M\ E}$

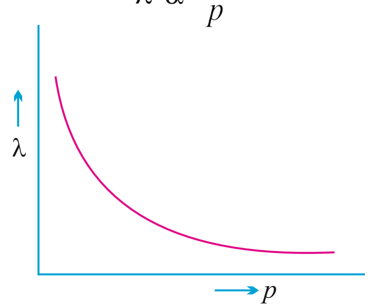
$\lambda_{photon} = 2.4 \times 10^{-8}$m, $\lambda_{electron} = 3.6 \times 10^{-10}$m

4. $\lambda = 3300 A^o$, $E = \dfrac{hc}{\lambda} = \dfrac{6.6\times10^{-34}\times3\times10^{8}}{3300\times10^{-10}\times1.6\times10^{-19}} eV \approx 3.8$ eV

Work function of M_o & Ni > 3.8 eV hence no photoelectron emission from M_o and Ni.

5. $\lambda = \dfrac{h}{p}$

$\Rightarrow \qquad \lambda \propto \dfrac{1}{p}$



6. Q

K.E.$_{max} \approx 1.3$ eV $\qquad$ As $\dfrac{h\nu_0}{e} = -2V$

7. $E = mc^2$, $h\nu = mc^2$, $m = \dfrac{h\nu}{c^2}$, no, it depends upon frequency.

8. $KE = h\nu - h\nu_0$. The electrons in the atom of metal occupy different energy levels, thus have different minimum energy required to be 'ejected' from the atom. So the e^- with higher energy will have higher kinetic energy.

9. Decreases, $\lambda = \frac{1}{\sqrt{V}} \therefore \frac{\lambda_1}{\lambda_2} = \frac{2\sqrt{2}}{1}$

11. $KE_{max} = hv - w_0 \quad \Rightarrow \quad KE_{max}$ decreases with increase in w_0.

12. Distance of closest approach is defined as the minimum distance between the charged particle and the nucleus at which initial kinetic energy of the particle is equal to electrostatic potential energy.

for α particle, $\frac{K\,Ze(2e)}{r} = \frac{1}{2} m v_{\alpha}^2$

$$r \propto \frac{1}{\text{K.E.}}$$

$\therefore \quad r$ will be halved.

16. The total binding energy of nuclei on two sides need not be equal. The difference in energy appears as the energy released or absorbed.

17. $n = 2$ as $r_n \,\alpha\, n^2$

19. Because radius of atom is very large than radius of nucleus.

20. Due to mass defect or different binding energies.

21. Decreases as number of neutrons decreases and number of protons increases. $N \rightarrow P + {}_{-1}e^0$

22. To counter repulsive coulomb forces, strong nuclear force required between neutron-neutron, neutron-proton and proton-proton.

24. For fusion, temperature required is from 10^6 to 10^7 K. So, to carry out fusion for peaceful purposes we need some system which can create and bear such a high temperature.

25. Nuclear forces are short range forces (within the nucleus) and do not obey inverse square law while coulomb forces are long range (infinite) and obey inverse square law.

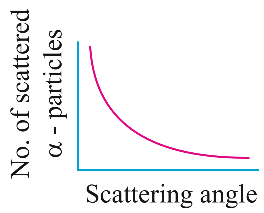
26.
$$\left(\frac{A}{8A}\right) = \left(\frac{1}{2}\right)^{t/T_{1/2}}$$

or
$$\left(\frac{1}{2}\right)^{3} = \left(\frac{1}{2}\right)^{t/3}$$

or
$$3 = \frac{t}{3}$$

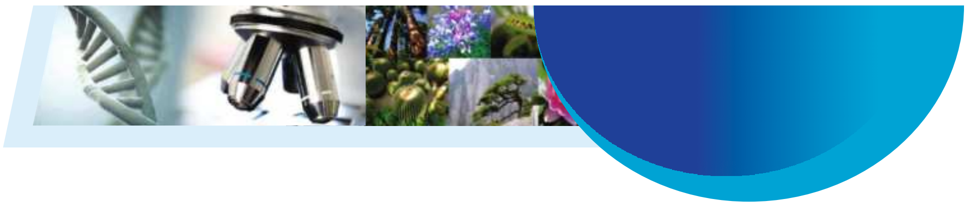
$\Rightarrow$
$$t = 9 \text{ days.}$$

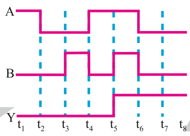
28.



29. $$V_0 = (E - \phi_0)/e = \frac{(25-7)eV}{e} = 18V.$$

❑❑





Unit IX

Electronic Devices

Unit IX

ELECTRONIC DEVICES

KEY POINTS

ELECTRONIC DEVICES

1. Solids are classified on the basis of

(i) Electrical conductivity	**Resistivity**	**Conductivity**
Metals	$\rho(\Omega m)$	$\sigma(Sm^{-1})$
	$10^{-2} - 10^{-8}$	$10^{2} - 10^{8}$
Semi-conductors	$10^{-5} - 10^{6}$	$10^{-6} - 10^{5}$
Insulators	$10^{11} - 10^{19}$	$10^{-19} - 10^{-11}$

(ii) Energy Bands **(a) Metals →**

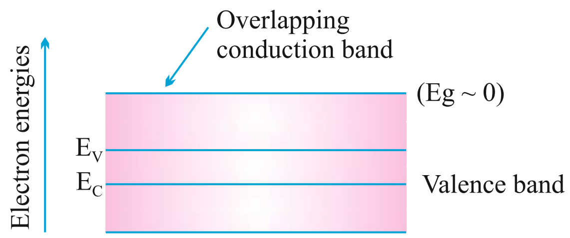


Fig. (*a*)

(b) Insulators →

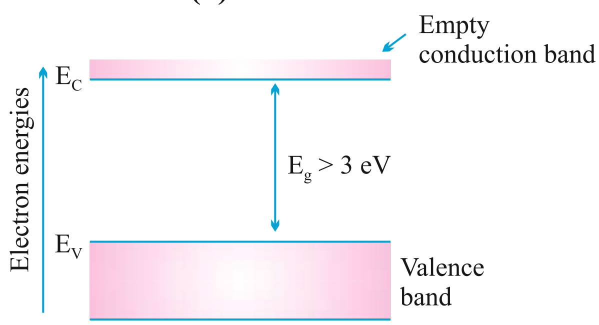


Fig (*b*)

(c) Semiconductors →

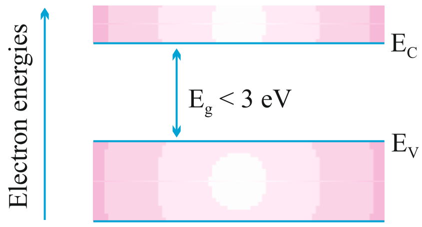


Fig (*c*)

2. Types of Semi-conductors

2 Types of semi-conductors

- Elemental
  Si, Ge
- Compound
  - Inorganic
    CdS, GaAS,
    CdSe, InP etc.
  - Organic, Anthracene
    Doped Pthalocyamines etc.

3. In intrinsic semiconductors (Pure Si, Ge) carrier (electrons and holes) are generated by breaking of bonds within the semiconductor itself. In extrinsic semiconductors carriers (*e* and *h*) are increased in numbers by 'doping'.

4. An intrinsic semiconductor at 0 K temperature behaves as an insulator.

5. Pentavalent (donor) atom (As, Sb, P etc) when doped to Si or Ge give *n*-type and trivalent (acceptor) atom (In, Ga, Ag, etc) doped with Si or Ge give *p*-type semiconductor. In *n*-type semiconductor electrons are the majority charge carriers & in *p*-type holes are the majority charge carriers.

6. Net charge in *p*-type or *n*-type semiconductor remains zero.

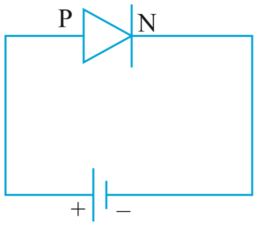
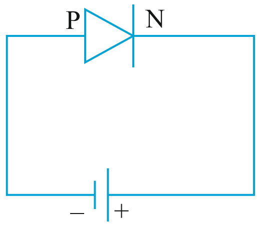
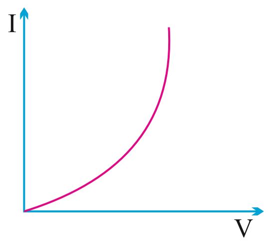
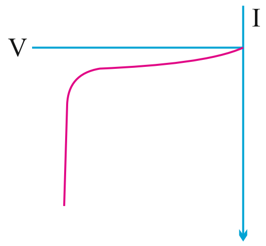
7. Diffusion and drift are the two processes that occur during formation of *p-n* junction.

8. Diffusion current is due to concentration gradient and drift current is due to electric field.

9. In depletion region movement of electrons and holes depleted it of its free charges.

10. *p-n* Junction is the most important semiconductor device because of its different behaviours in forward biasing (as conductor for $V > V_b$) and reverse biasing (as insulator for $V < V_b$) a *p-n* junction can be used as Rectifier, LED, photodiode, solar cell etc.

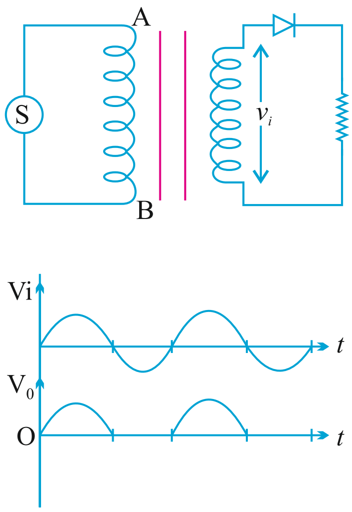
Differences between FB and RB junction diodes :

Forward Bias	Reverse Bias
	
Depletion layer is decreased	Depletion layer is increased
Lower resistance	Higher resistance
$R \rightarrow 0$ ideal diode	$R \rightarrow \infty$ ideal diods
	
Current due to majority charge carrier.	Current due to minority charge carrier.

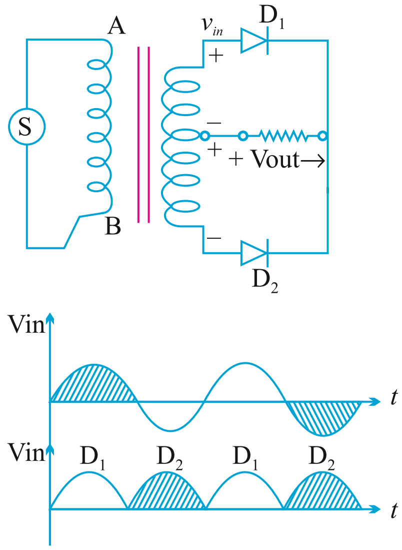
11. In half wave rectifier frequency output pulse is same as that of input and in full wave rectifier frequency of output is double of input.

Rectifier p-n junction diode

Half Wave Rectifier



Full Wave Rectifier



12. When a zener diode is reverse biased, voltage across it remains steady for a range of currents above zener breakdown. Because of this property, the diode is used as a voltage regulator.

QUESTIONS

Chapter 14- Semiconductor Electronics : Materials, Devices and Simple Circuits

1. Let n_h and n_e be the number of holes and conduction electrons in an extrinsic semiconductors. Then—

   (a) $n_h > n_h$ (b) $n_h = n_e$

   (c) $n_h < n_e$ (c) $n_h \neq n_e$

2. Electric conduction in a semiconductor takes place due to

   (a) electrons only (b) holes only

   (c) both electrons and holes (d) neither electrons nor holes

3. In a p-type semiconductor, the current conduction is due to—

   (a) holes (b) protons

   (c) electrons (d) neutrons

4. What happens to the resistance of semiconductors on heating?

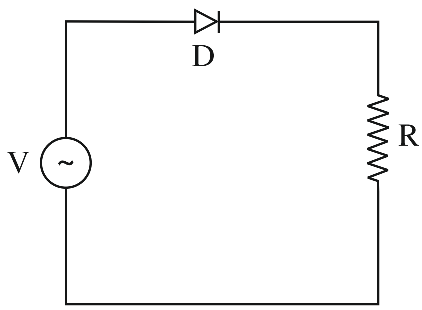
   (a) Increases

   (b) decreases

   (c) Remains same

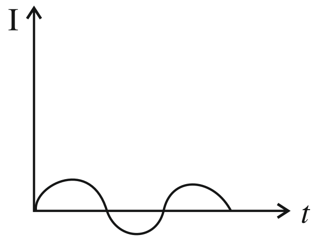
   (d) First decreases than increase

5. A half wave rectifier circuit is constructed using a p-n function diode D, load resistance R and AC source as shown below:

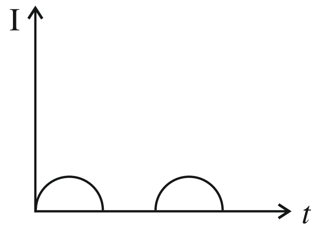


The output current through R varies as—

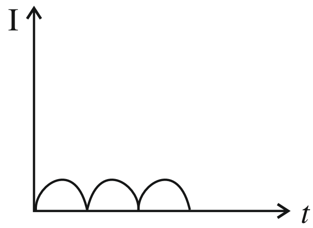
(a)



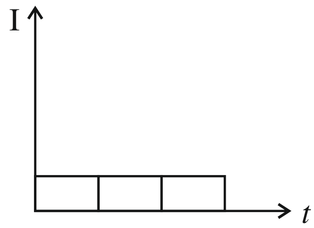
(b)



(c)



(d)



Answers

1. (d) 2. (c) 3. (a) 4.(b) 5. (b)

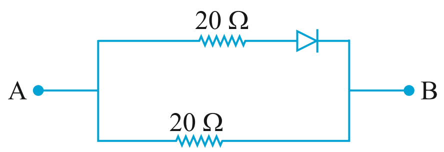
SHORT ANSWER QUESTIONS (2 MARKS)

1. If the frequency of the input signal is *f*. What will be the frequency of the pulsating output signal in case of :

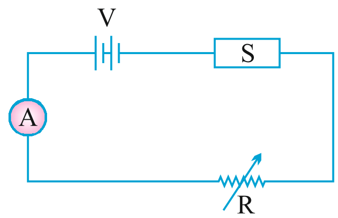
   (i) half wave rectifier ? (ii) full wave rectifier ?

2. Find the equivalent resistance of the network shown in figure between point A and B when the *p-n* junction diode is ideal and :

   (i) A is at higher potential (ii) B is at higher potential



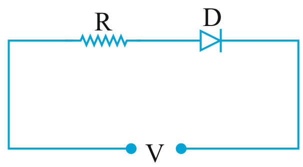
3. Potential barrier of *p-n.* junction cannot be measured by connecting a sensitive voltmeter across its terminals. Why ?
4. Diode is a non linear device. Explain it with the help of a graph.
5. A *n*-type semiconductor has a large number of free electrons but still it is electrically neutral. Explain.
6. The diagram shows a piece of pure semiconductor S in series with a variable resistor R and a source of constant voltage V. Would you increase or decrease the value of R to keep the reading of ammeter A constant, when semiconductor S is heated ? Give reason.



7. In the given circuit, D is an ideal diode. What is the voltage across R ? When the applied voltage V makes the diode.

   (a) Forward bias ?

   (b) Reverse bias ?



8. What are the characteristics to be taken care of while doping a semiconductor ? Justify your answer.

Ans. (a) The size of the dopant atom should be such that it do not distort the pure semiconductor lattice.

(b) It can easily contribute a charge carrier on forming covalent bond with pure Si or Ge.

9. Give two examples each of
   (i) elemental (ii) compound inorganic semiconductors
   (iii) compound organic semiconductors

10. Show the donor energy level in energy band diagram of *n*-type semiconductor.

11. Show the acceptor energy level in energy band diagram of *p*-type semiconductor.

12. What is the value of knee voltage in

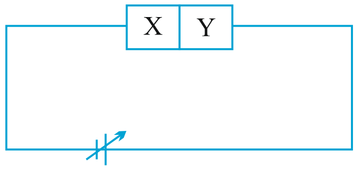
   (a) Ge junction diode.

   (b) Si junction diode.

13. On the basis of energy band diagrams, distinguish between metals, insulators and semiconductors.

14. Two semiconductor materials X and Y shown in the given figure, are made by doping germanium crystal with indium and arsenic respectively. The two

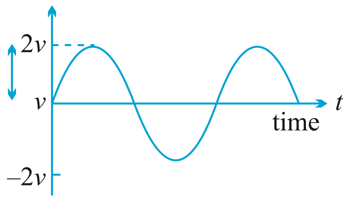
are joined at lattice level and connected to a battery as shown.



(i) Will the junction be forward biased or reversed biased ?

(ii) Sketch a V-I graph for this arrangement.

15. Following voltage waveform is fed into half wave rectifier that uses a silicon diode with a threshold voltage of 0.7 V. Draw the output voltage waveform.



SHORT ANSWER QUESTIONS (3 MARKS)

1. What is depletion region in *p-n* junction diode. Explain its formation with the help of a suitable diagram.

2. What is rectification ? With the help of labelled circuit diagram explain half wave rectification using a junction diode.

3. With the help of a circuit diagram explain the V–I graph of a *p-n* junction in forward and reverse biasing.

4. What is *p-n* junction ? How is *p-n* junction made ? How is potential barrier developed in a *p-n* junction.

5. Give three differences between forward bias and reverse bias.

6. Draw the characteristic (V-I) curve of a junction diode. Write down in your graph the approximate values of voltage and current. On the basis of your graph, explain how a junction diode works in forward biasing and reverse biasing.

7. Write three differences between *n*-type semiconductor and *p*-type semiconductor.

LONG ANSWER QUESTIONS (5 MARKS)

1. What is *p-n* junction diode ? Define the term dynamic resistance for the junction. With the help of labelled diagram, explain the working of *p-n* junction as a full wave rectifier.

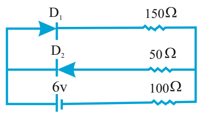
NUMERICALS

1. In a *p-n* junction, width of depletion region is 300 nm and electric field of 7×10^5 V/m exists in it.

   (i) Find the height of potential barrier.

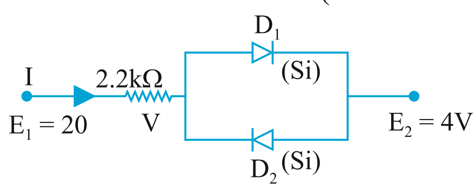
   (ii) What should be the minimum kinetic energy of a conduction electron which can diffuse from the *n*-side to the *p*-side ?

2. The circuit shown in the figure contains two diodes each with a forward resistance of 50 ohm and with infinite reverse resistance. If the battery voltage is 6 V, Find the current through the 100 ohm resistance (in ampere).

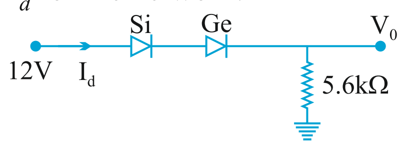


Ans. 0.02A

3. Determine the current I for the network. (Barrier voltage for Si diode is 0.7 volt).



4. Determine V_0 and I_d for the network.

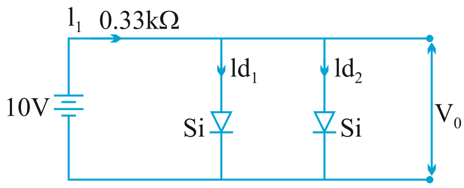


5. A *p-n* junction is fabricated from a semiconductor with a band gap of 2.8 eV. Can it detect a wavelength of 600 nm ? Justify your answer.

Ans. Eneryg of photon of wavelength 600 $nm = 2.07$ eV .... working condition of photodiode $h\nu >$ Eg but Eg $> h\nu$ so photodiode can not detec the given wavelength

6. Determine V_0, I_{d1} and I_{d2} for the given network. Where D_1 and D_2 are made of silicon.

$$\left(I_{d_1} = I_{d_2} = \frac{I_1}{2} = 14.09 \text{ mA}\right)$$



Ans. $V_0 = V_{si} = 0.7V$

$$I_1 = \frac{10 - 0.7}{.33 \times 10^3}$$

$$= 28.18 \text{ mA}$$

$$\therefore \quad I_{d_1} = I_{d_2} = \frac{28.18}{2}$$

$$= 14.09 \ mA$$

7. Pure Si at 300 K has equal electron (n_e) and hole (n_h) concentration of $1.5 \times 10^{16}/m^3$. Doping by indium increases n_h to $4.5 \times 10^{22}/m^3$. Calculate n_e in the doped silicon. [**Ans. :** $5 \times 10^9 \ m^{-3}$]

SHORT ANSWER QUESTIONS (2 MARKS)

1. Frequency of output in half wave rectifier is *f* and in full have rectifier is 2*f*.

2. Equivalent resistance is

(i) 10Ω, As diode is forward biased

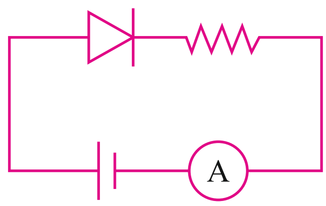
(ii) 20Ω, diode is reverse biased

3. Because there is no free charge carrier in depletion region.

6. On heating S, resistance of semiconductors S is decreased so to compensate the value of resistance in the circuit R is increased.

Assertion - Reason question (Semiconductor)

1. Assertion : A pure semiconductor has negative temperature coefficient.
   Reason : On increasing temperature, charge carriers are generated.
2. Assertion : In the given diagram, the ammeter will NOT show any reading (consider diode to be ideal)



   Reason : An ideal diode offers infinite resistance in forward bias.
3. Assertion: Electron has higher mobility than hole in a semi-conductor
   Reason: The mass of electron is less than hole.

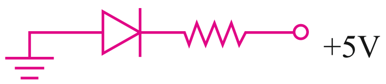
4. Assertion: A p-type semi-conductor is a positive type crystal
   Reason: A p-type semi -conductor is an uncharged crystal

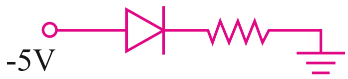
5. Assertion : In a n-type semiconductor holes are majority carriers & electrons are minority carriers.
   Reason : The net charge on a p-type semiconductor is positive.

Case Study Question

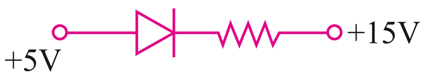
When an intrinsic semiconductor is doped with group-15 and group-13 elements we get a new semiconductor called extrinsic semiconductor. Adding impurities to extrinsic semiconductors is called doping, when the two extrinsic semiconductors are joined the resultant device is called junction diode. Applying suitable voltage across a diode is called biasing . There are two types of biasing- forward biasing and reverse biasing. We have different types of special purpose diodes used in specific biasing mode according to the purpose.

1. When X is added in a pure silicon we get a p-type semiconductor. The X is-
   a) Carbon
   b) Germanium
   c) Indium
   d) Arsenic
2. An intrinsic semiconductor is doped with an impurity, the resultant semiconductor contains electron as mojority carrier- The impurity is-
   a) Aluminum
   b) Indium
   c) Phosphorous
   d) Carbon
3. Ideal diode has resistance of ______ Ω in forward biasing
   a) 10
   b) 0
   c)
   d) 100
4. In which of the following figure, the diode is forward biased -

a) 

b) 

c) 

d) 

5. Which of the following is true for a diode in forward bias-

a) The width of depletion layer is increased

b) The height of potential barrier is decreased

c) The conduction is due to minority charge carriers

d) The junction resistance is increased

Answers Assertion-Reasoning Questions

1. (a) 2. (d) 3. (a) 4. (d) 5. (d)

Case study questions

1. (c) 2. (c) 3. (c) 4. (c) 5. (b)

NUMERICALS

1. (i) $V = Ed = 7 \times 10^5 \times 300 \times 10^{-9} = 0.21$ V

(ii) Kinetic energy = eV = 0.21 eV

3. $$I = \frac{E_1 - E_2 - V_d}{R} = \frac{20 - 4 - 0.7}{2.2 \times 10^3} = 6.95 \text{ mA}$$

4. $V_0 = E - V_{si} - V_{Ge} = 12 - 0.7 - 1.1 = 12 - 1.8 = 10.2$ V

$$I_d = \frac{V_0}{R} = \frac{10.2}{5.6 \times 10^3} = 1.82 \text{ mA}. \quad V_0 = 12 - 0.7 - 0.3 = 11 \text{ V}$$

$$I_d = \frac{11}{5.6 \times 10^3} = 1.96 \text{ mA}$$

PRACTICE QUESTION PAPER(SOLVD)

SUBJECT: PHYSICS (THEORY)

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

General Instructions:

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

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

(3) All the sections are compulsory.

(4) Section A contains sixteen questions, twelve MCQ and four Asser Reasoning based of 1 mark each, Section B contains five questions of two marks each, Section C contains seven questions of three marks each, Section D contains two case study based question four marks each and Section E contains three long arts questions of five marks each.

(5) There is no overall choice. However, an internal choice has b provided in one question in Section B, one question in Section C. question in each CBQ in Section D and all three questions in Sec E. You have to attempt only one of the choices in such question

(6) Use of calculators is not allowed.

(7) You may use the following values of physical constants w necessary

(i) $c = 3 \times 10^8 m/s$

(ii) $m_e = 9.1 \times 10^{-31}$ kg

(iii) $e = 1.6 \times 10^{-19}$ C

(iv) $\mu_0 = 4\pi \times 10^{-7}$ TmA^{-1}

(v) $h = 6.63 \times 10^{-34}$ Js

(vi) $\varepsilon_0 = 8.854 \times 10^{-12}$ $C^2N^{-1}m^{-2}$

(vii) Avogadro's number = 6.023×10^{23} per gram mole

SECTION-A

1. A capacitor of capacitance C has charge Q and stored energy is W. If the c increased to 2 Q, the stored energy will be

(a) $\frac{W}{4}$ (b) $\frac{W}{2}$ (c) 2W (d) 4W

2. There is an electric field in the X-direction. If the work done in moving a charge of 0.2 C through a distance of 2 m along a line making an angle of 60° with X-axis is 4 J, then what is the value of E ?

(a) $\sqrt{3}$ NC^{-1} (b) $4NC^{-1}$

(c) 5 NC^{-1} (d) 20 NC^{-1}

3. A photo sensitive metallic plate exposed to white light emits electrons. For which of the following colours of light, the stopping potential will be minimum?

(a) Blue (b) Yellow

(c) Red (d) Violet

4. To explain his theory, Bohr used

(a) Conservation of linear momentum

(b) Quantization of angular momentum

(c) Conservation of quantum frequency

(d) None of these

5. Susceptibility of ferromagnetic substance is

(a) > 1 (b) < 1

(c) zero (d) 1

6. If resistance of a galvanometer is 6 Ω and it can measure a maximum current of 2 A. Then required shunt resistance to convert it into an ammeter reading up to 6 A, will be

(a) 2Ω (b) 4Ω

(c) 3Ω (d) 5Ω

7. An alpha particle is moving along negative z axis with a constant speed. If a uniform Magnetic Field is applied along positive x axis then find the direction of acceleration experienced by alpha particle

(a) Negative z axis (b) Positive z axis

(c) Positive y axis (d) Negative y axis

8. The ratio of time period of α particle to that of proton circulating with same speed in the same uniform magnetic field is

(a) $\sqrt{2}:1$ (b) $1:\sqrt{2}$

(c) 1 :2 (d) 2:1

9. The core of transformer is laminated to

(a) prevent it from moisture (b) prevent it from noise

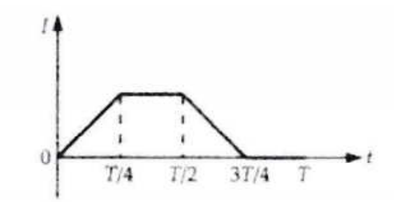
(c) prevent it from heat (d) reduce the loss of energy.

10. Which radiations are used in treatment of muscles ache?

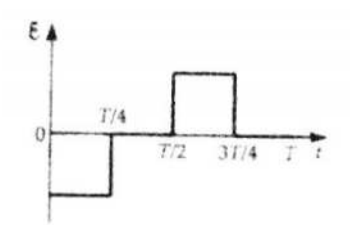
(a) infrared (b) ultraviolet

(c) microwave (d) X-rays.

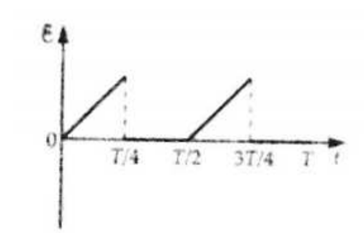
11. The current I in a coil varies with time as shown in the figure. The variation of induced emf e with time would be



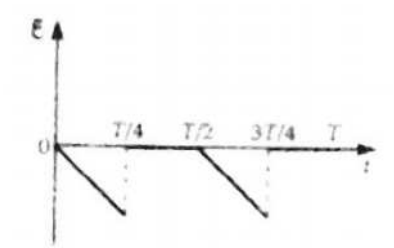
(a)



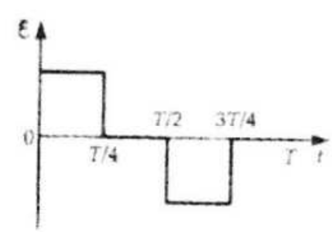
(b)



(c)



(d)



12. The longest wavelength in Balmer series of hydrogen spectrum will be

(a) 6557 A (b) 1216 A

(c) 4800 A (d) 5600 A

For Questions 13 to 16, two statements are given -one labelled Assertion (A) and other labelled Reason (R). Select the correct answer to these questions from the options as given below.

(a) If both Assertion and Reason are true and Reason is correct explanation of Assertion.

(b) If both Assertion and Reason are true but fceaion is not the correct explanation of Assertion.

(c) If Assertion is true but Reason is false.

(d) If both Assertion and Reason are false.

13. **Assertion.** A photon has no rest mass, yet it carries definite momentum.

    Reason. Momentum of photon is due to its energy and hence its equivalent mass.

14. **Assertion.** At a fixed temperature, silicon will have a minimum conductivity when it has a smaller acceptor doping.

    Reason. The conductivity of an intrinsic semiconductor is slightly higher than that of a lightly doped p-type.

15. **Assertion.** A metallic shield in the form of a hollow shell may be built to block an electric field.

    Reason. In a hollow spherical shield, the electric field inside it is zero at every point.

16. **Assertion.** Endoscopy involves use of optical fibres to study internal organs.

    Reason. Optical fibres are based on phenomenon of total internal reflection.

SECTION-B

17. Draw the circuit diagram of a junction diode as a half-wave rectifier. Draw the input and output waveforms.

18. Work function of sodium is 2.3 eV. Does sodium show photoelectric emission for orange light (λ = 6800 Å) ? Given h = 5.63×10^{-34}Js.

19. Calculate the value of the angle of incidence when a ray of light incident on one face of an equilateral glass prism produces the emergent ray, which just grazes along the adjacent face. Refractive index of the prism is $\sqrt{2}$.

20. When 5 V potential difference is applied across a wire of length 0.1 m, the drift speed of electrons is 2.5×10^{-4}m / s. If the electron density in the wire is $8 \times 10^{28}\text{m}^{-3}$, calculate the resistivity of the material of wire.

21. How will the magnifying power of a refracting type astronomical telescope be affected on increasing for its eyepiece (i) the focal length and (ii) the aperture? Justify your answer.

OR

In a telescope, the objective has a large aperture while the eyepiece has a small aperture. Why?

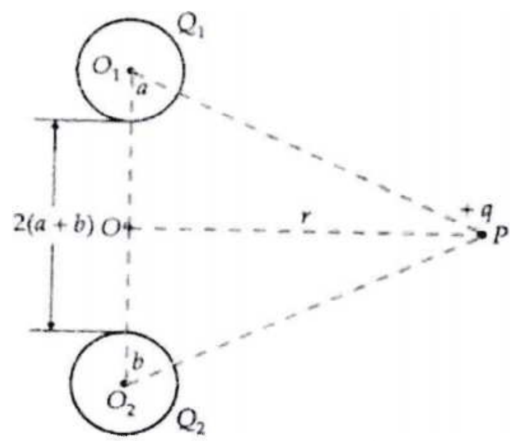
SECTION-C

22. Calculate the binding energy per nucleon (B.E./nucleon) in the nuclei of $^{31}_{15}$P Given:

$$\left[{}^{31}_{15}\text{P}\right] = 30.97376 \text{ amu}, m\left[{}^{1}_{0}n\right] = 1.00865 \text{ amu}$$

$$m\left[{}^{1}_{1}\text{H}\right] = 1.00782 \text{ amu}$$

23. Find the P.E. associated with a charge 'q' if it were present at the point P with respect to the 'set-up' of two charged spheres, arranged as shown in Figure. Here O is the mid-point of the line O_1O_2.



24. The energy of the electron, in the hydrogen atom, is known to be expressible in the form

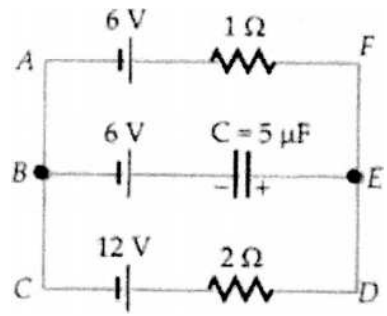
$$E_n = -\frac{13.6eV}{n^2} n = 1, 2, 3...$$

Use this expression to show that the

(i) electron in the hydrogen atom cannot have an energy of- 6.8 eV.

(ii) spacing between the lines (consecutive energy levels) with in the given set of the observed hydrogen spectrum decreases as n increases.

25. In the given circuit, with steady current, calculate the potential difference across the capacitor and the charge stored in it.



26. Apply Biot-Savart law to find the magnetic field due to a circular current carrying loop at a point on the axis of the loop.

27. Name the e.m. waves having the wavelength ranges :

(a) 10 nm to 10^{-3} nm (b) 10^{-7}m to 10^{-9} m

(c) 0.1 m to 1 mm

How are these waves generated? Write their two uses.

28. Derive an expression for the self-inductance of a long solenoid. State the factors on which the self inductance of a coil depends.

OR

A metal disc of radius R rotates with an angular velocity ω about an axis perpendicular to its plane passing through its centre in a magnetic field B acting perpendicular to the plane of the disc. Calculate the induced emf between the rim and the axis of the disc.

SECTION-D

Case Study Based Questions

29. Read the following paragraph and answer the questions that follow

A pure semiconductor germanium or silicon, free of every impurity is called intrinsic semiconductor. At room temperature, a pure semiconductor has very small number of current carriers (electrons and holes) Hence its conductivity is low.

When the impurity atoms of valance five or three are doped in a pure semiconductor, we get respectively n-type or p- type extrinsic semiconductor. In case of doped semiconductor $n_e.n_h = n_i^2$. Where n_e and n_h are the number density of electron and hole charge carriers in a pure semiconductor. The conductivity of extrinsic semiconductor is much higher than that of intrinsic semiconductor.

(i) Which of the following statements is not true?

a. The resistance of intrinsic semiconductor decreases with increase of temperature.

b. Doping pures Si with trivalent impurities gives p- type semiconductors.

c. The majority charges in n-type semiconductors are holes.

d. A p-n junction can act as semiconductor diode.

(ii) The impurity atoms with which pure Si should be doped to make a p-type semiconductor is

a. Phosphorus b. Boron

c. Arsenic d. Antimony

(iii) Holes are majority charge carriers in

a. Intrinsic semiconductors.

b. Ionic Solids

c. p-type semiconductors

d. Metals

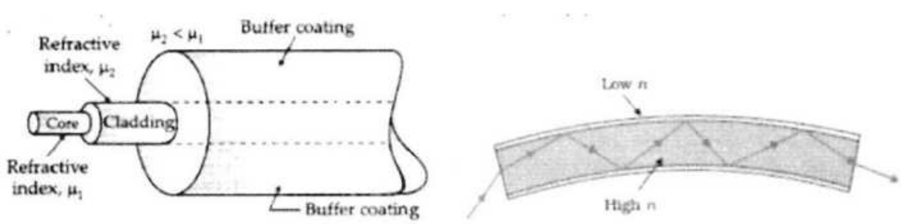
(iv) At absolute zero, Si acts as

a. Non- metal　　b. Metal

c. Insulator　　d. None of these

30. **Read the following paragraph and answer the questions that follow**

Optical fibres: Now-a-days optical fibres are extensively used for transmitting audio and video signals through long distances. Optical fibres too make use of the phenomenon of total internal reflection. Optical fibres are fabricated with high quality composite glass/quartz fibres. Each fibre consists of a core and cladding. The refractive index of the material of the core is higher than that of the cladding. When a signal in the form of light is directed at one end of the fibre at a suitable angle, it undergoes repeated total internal reflections along the length of the fibre and finally comes out at the other end. Since light undergoes total internal reflection at each stage, there is no appreciable loss in the intensity of the light signal. Optical fibres are fabricated such that light reflected at one side of inner surface strikes the other at an angle larger than the critical angle. Even if the fibre is bent, light can easily travel along its length. Thus, an optical fibre can be used to act as an optical pipe.



(i) Which of the following statement is not true.

(a) Optical fibres is based on the principle of total internal reflection.

(b) The refractive index of the material of the core is less than that of the cladding.

(c) an optical fibre can be used to act as an optical pipe.

(d) there is no appreciable loss in the intensity of the light signal while propagating through an optical fibre.

(ii) What is the condition for total internal reflection to occur?

(a) angle of incidence must be equal to the critical angle.

(b) angle of incidence must be less than the critical angle.

(c) angle of incidence must be greater than the critical angle.

(d) None of the above.

(iii) Which of the following is not an application of total internal reflection?

(a) Mirage

(b) Sparkling of diamond

(c) Splitting of white light through a prism.

(d) Totally reflecting prism.

(iv) Optical fibres are used extensively to transmit

(a) Optical Signal

(b) current

(c) Sound waves

(d) None of the above

SECTION-E

31. Discuss the variation of the angle of deviation with that of the angle of incidence for a ray of light passing through a prism. Derive an expression for the refractive index of the material of a prism in terms of the angle of prism and the angle of minimum deviation.

OR

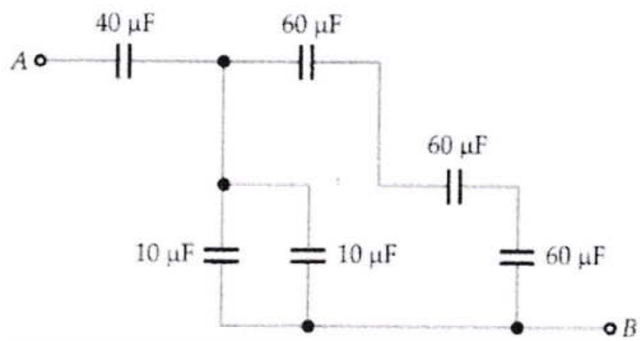
(i) Find the ratio of intensities at two points in a screen in Young's double slit experiment, when waves from the two slits have path difference of (a) 0 and (b) $\lambda/4$.

(ii) Deduce an expression for fringe width in Young's double slit experiment

SECTION-E

32. (i) Define electrical capacitance of conductor. On which factors does it depend?

(ii) Find the equivalent capacitance of the combination of capacitors between the points A and B as shown in Figure. Also calculate the total charge that flows in the circuit when a 100 V battery is connected between the points A and B.



OR

(i) Derive an expression for the potential energy of a dipole in a uniform electric field. Discuss the conditions of stable and unstable equilibrium.

(ii) Three charges - q, + Q and - q are placed at equal distances on a straight line. If the potential energy of the system of three charges is zero, find the ratio Q/q.

33. (i) What is a transformer? Explain the principle with diagram of a transformer.

(ii) Write any two ways of energy losses in a transformer?

(iii) The primary coil of an ideal step-up transformer has 100 turns and the transformation ratio is also 100. The input voltage and the power are 220 V and 1100 W respectively. Calculate :

(a) number of turns in the secondary

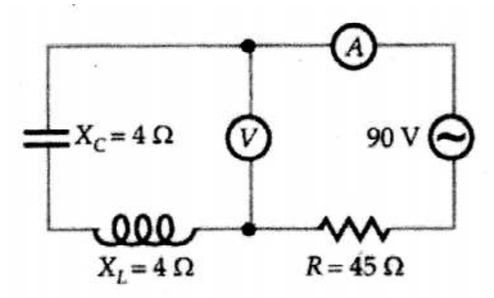
(b) the current in the primary

OR

(i) What do you mean by the resonance condition of a series LCR-circuit ? Calculate its resonant frequency.

(ii) A resistor of 50 ohm, an inductor of $(20/\pi)$ H and a capacitor of $(5/\pi)\mu$F are connected in series to a voltage source 230 V, 50 Hz. Find the impedance of the circuit.

(iii) What will be the readings in the voltmeter and ammeter of the circuit shown in Figure?



PRACTICE PAPER (SOLVED)

(SOLUTION)

SECTION A

1. [d] As Energy depends directly on square of charge stored in the capacitor.
2. [d] Here q = 0.2 C, s = 2m, 9 = 60°, W = 4J But W = Fscosθ = qEscosθ E = $20NC^{-1}$.
3. [c] Red
4. [b] To explain his theory, Bohr used quantization of angular momentum.
5. [a] Susceptibility of ferromagnetic substance is greater than 1
6. [c] lg × G = I_s × S 2 × 6 = 4 × S S = 3Ω.
7. [d] Negative Y axisF = q (v × B) = (–z) X (+x) = –y
8. [d] $T = \frac{2\pi m}{qB}$ $\frac{T_\alpha}{T_p} = \frac{m_\alpha}{m_p} . \frac{q_p}{q_x} = \frac{4m_p}{m_p} . \frac{e}{2e} = 2:1$
9. (d) reduce the loss of energy.
10. [a] Infrared
11. (a) $\varepsilon = -L\frac{dt}{dt}$

    0 to $\frac{T}{4}, \frac{dI}{dt}$ = +ve constant, ε = –ve constant

    $\frac{T}{4}$ to $\frac{T}{2}, \frac{dI}{dt} = 0, \varepsilon = 0$

    $\frac{T}{2}$ to $\frac{3T}{4}, \frac{dI}{dt} - ve$ constant, $\varepsilon = +ve$ constant

    $\frac{3T}{4}$ to T, $\frac{dI}{dt} = 0, \varepsilon = 0$.

12. [a] For longest wavelength in Balmer series, $n_1 = 2$ and $n_2 = 3$.

$$\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = 1.098 \times 10^7 \left[\frac{1}{2^2} - \frac{1}{3^2}\right]$$

$$\lambda = \frac{36 \times 10^{-7}}{5 \times 1.098} m$$

$= 6577 \times 10^{-10}$m

$= 6557$ Å.

13. (a) The moving mass m of a photon is given by

$$E = mc^2 = h\nu \qquad \therefore\ m = \frac{E}{c^2} = \frac{h\nu}{c^2}$$

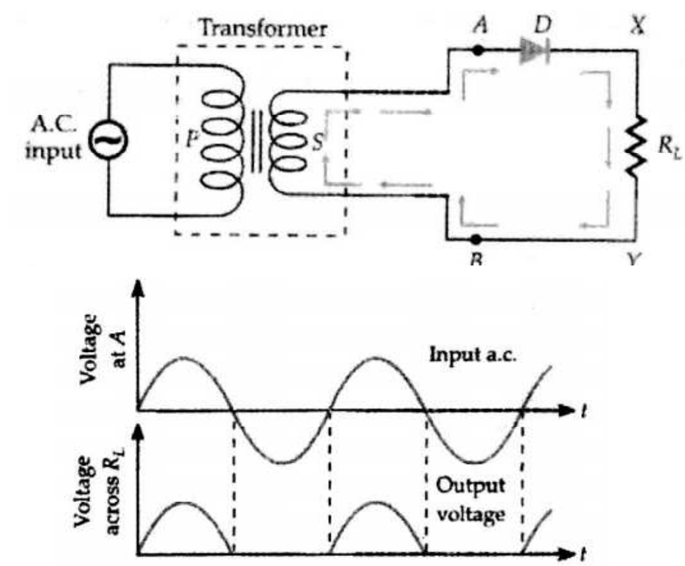
Momentum, $p = mc = \dfrac{h\nu}{c} = \dfrac{h}{\lambda}$.

14. (c) The conductivity of an intrinsic semiconductor is less than that of a lightly doped semiconductor.

15. (a) Both assertion and reason are true and reason is the correct explanation of the assertion.

16. (a) Both assertion and reason are correct and reason is the correct explanation of assertion.

17. Circuit Diagram



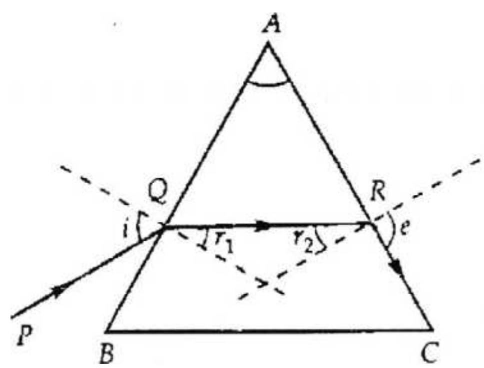
18. Energy of a photon of orange ligth is

$$E = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{68 \times 10^{-8}}$$

$$= \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{68 \times 10^{-8} \times 1.6 \times 10^{-19}} \text{eV} = 1.83\text{eV}$$

As the energy of a photon of orange light is less than the work function of sodium (2.3 eV) so sodium does not show photoelectric emission with orange light.

19. As shown in the figure, let r_2 be the angle of incidence at face AC. For the grazing ray RC, the angle of emergence, e = 90°.



$$\therefore \ \mu = \frac{\sin 90°}{\sin r_2} = \frac{1}{\sin r_2} = \sqrt{2}$$

or $\sin r_2 = \frac{1}{\sqrt{2}} \Rightarrow r_2 = 45°$

But $r_1 + r_2 = \text{A}$ or $r_1 + 45° = 60°$

$\therefore \ r_1 = 15°$

Let i be the angle of incidence at face AB. Then,

$$\mu = \frac{\sin i}{\sin r_1} \text{ or } \sqrt{2} = \frac{\sin i}{\sin 15^\circ}$$

$$\therefore\ \mathrm{I} = \sin^{-1}(\sqrt{2}\sin 15^\circ).$$

20. $\mathrm{R} = \rho\frac{1}{\mathrm{A}} = \text{and } \mathrm{I} = \mathrm{enAv}_d$ $\quad\therefore\ \mathrm{V} = \mathrm{RI} = \rho\frac{1}{\mathrm{A}}.\mathrm{enAv}_d$

Or $\rho = \dfrac{V}{env_d l}$

$$= \frac{5}{1.6\times10^{-19}\times8\times10^{-28}\times2.5\times10^{-4}\times0.1}$$

$= 1.26 \times 10^5\ \Omega\mathrm{m}.$

21. (i) As $m = \dfrac{f_0}{f_e}$, so that magnifying decreases when focal length of eyepiece increases.

(ii) Magnifying power is not affected by the increase in. aperture of the eyepiece.

OR

The objective of large aperture has a large light gathering capacity and it forms bright images of even distant faint stars. Moreover, the large aperture of the objective increases the resolving power of the telescope.

The eyepiece of small aperture is taken so that entire light forming the final image may enter the small pupil of the eye and a brighter image is seen.

22. The nucleus ${}^{31}_{15}\mathrm{P}$ contains 15 protons and 16 neutrons.

Mass of 15 protons = 15 × 1.00782 = 15.1173 amu

Mass of 16 neutrons = 16 × 1.00865 = 16.1384 amu

Total mass = 31.2557 amu 31

Mass of ${}^{31}_{15}\mathrm{P}$ nucleus = 30.97376 amu 15

Mass defect, $\Delta m = 0.28194$ amu

$\Delta m \times 931$ MeV $= 0.28194 \times 931 = 262.436$ MeV

B.E./nucleon $= \dfrac{262.486}{31} = 8.47$ MeV

23. $r_1 = O_1P = \sqrt{r^2 + (2a+b)^2}$

$r_1 = O_2P = \sqrt{r^2 + (a+2b)^2}$

Potential at point P due to Q_1 and Q_2 is

$$V = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right]$$

P.E. associated with charge q at point P,

$$U = qV = \frac{q}{4\pi\varepsilon_0}\left[\frac{Q_1}{[r^2+(2a+b)^2]^{1/2}} + \frac{Q_2}{[r^2+(a+2b)^2]^{1/2}}\right]$$

24. Given $E_n = E_n = -\dfrac{13.6eV}{n^2}$

Putting n = 1, 2, 3......., we get

$E_1 = -\dfrac{13.6}{1^2} = -13.6eV;$

$E_2 = -\dfrac{13.6}{2^2} = -3.4eV$

$E_3 = -\dfrac{J3.6}{3^2} = -1.51eV;$

$E_4 = \dfrac{13.6}{4^2} = -0.85V$

$E_\infty = -\dfrac{16.6}{\infty 2} = 0$ eV

(i) Clearly, an electron in the hydrogen atom cannot have an energy of –6.8 eV

(ii) As the value of *n* increases, the energy difference between two consecutive energy levels decreases.

25. In the steady state (when the capacitor is fully charged), no current flows through the arm BE. In the loop ABCDEFA,

$$I = \frac{\text{Net emf}}{\text{Total resistance}} = \frac{(12-6)}{2+1} = 2A$$

Now, $V_{AF} = V_{BE}$

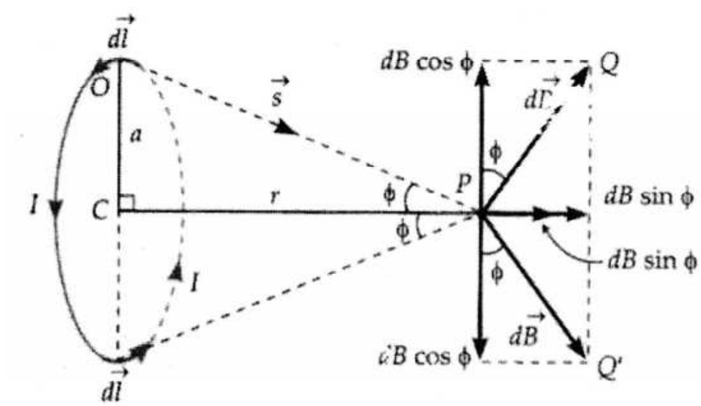
or $6 - 1 \times 2 = 6 - V_C$

$\therefore\ V_C = 2V$

Charge stored in the capacitor,

$Q = CV = 5\mu F \times 2V = 5\mu C$

26. Let the plane of the loop be perpendicular to the plane of paper. We wish to find field B at an axial point P at a distance r from the centre C.



Consider a current element d! at the top of the loop. It has an outward coming current.

If s be the position vector of point P relative to the element $\vec{dl}$, then from Biot-Savart law, the field at point P due to the current element is $dB = \frac{\mu_0}{4\pi} \cdot \frac{Idl \sin\theta}{s^2}$

Since $\vec{dl} \perp \vec{s}$, i.e., 9 =90°, therefore $dB = \frac{\mu_0}{4\pi}.\frac{Idl}{s^2}$

The field $d\vec{B}$ lies in the plane of paper and is perpendicular to *s*, as shown by $\overrightarrow{PQ}$. Let ϕ be the angle between OP and CP. Then dB can be resolved into two rectangular components.

dB sin ϕ along the axis,

dB cos ϕ perpendicular to the axis

$$B = \int dB \sin\phi$$

But sinϕ = $\frac{a}{s}$ and $dB = \frac{\mu_0}{4\pi}.\frac{Idl}{s^2}$

$$B = \int \frac{\mu_0}{4\mu}, \frac{Idl}{s^2}, \frac{a}{s}$$

Since μ_0 and I are constant, and s and a are same for all points on the circular loop, we have

B = $\frac{\mu_0 Ia}{4\pi s^3}\int dl = \frac{\mu_0 Ia}{4\pi s^3}.2\pi a = \frac{\mu_0 Ia^2}{2s^3}$

or B = $\frac{\mu_0 Ia^2}{2(r^2+a^2)^{3/2}}$ $[\because s = (r^2+a^2)^{1/2}]$

$$\vec{B} = \frac{\mu_0 Ia^2}{2(r^2+a^2)^{3/2}}\hat{i}$$

As the direction of the field is along +ve X-direction, so we can write

$$\vec{B} = \frac{\mu_0 Ia^2}{2(r^2+a^2)^{3/2}}\hat{i}$$

If the coil consists of N turns, then B = $B = \frac{\mu_0 Ia^2}{2(r^2+a^2)^{3/2}}$

27.

Wavelength range	EM waves	Production	Uses
10 nm to 10^{-3} nm	X-rays	Bombarding high energy electrons on a metal target/ inner shell electrons.	(i) In medical diagnosis (ii) In the study of crystal structure.
10^{-7} mto 10^{-9}m	Ultraviolet rays	Movements of inner shell electrons from higher to lower energy leveli, in atoms	(i) In LASIK eye surgery. (ii) ln UV lamps to kill germs in water purifiers.
0.1 m to 1 mm	Microwaves	Klystron or magnetron valve and Gunn diode	(i) In radar systems (ii) In microwave - ovens

28. Self-inductance of a long solenoid. Consider a long solenoid of length I and radius r with r << I and having n turns per unit length. If a current I flows through the coil, then the magnetic field inside the coil is almost constant and is given by

$B = \mu_0 nIA$

Magnetic flux linked with each turn

$= BA = \mu_0 nIA$

where $A = \pi r^2$ = the cross-sectional area of the solenoid.

$\therefore$ Magnetic flux linked with the entire solenoid is

ϕ = Flux linked with each turn × total number of turns

$= \mu_0 n IA \times nl = \mu_0 n^2 IAl$

But $\phi = LI$

$\therefore$ Self-inductance of the long solenoid is

$L = \mu_0 n^2 lA$

If N is the total number of turns in the solenoid, then $n = N/l$ and so

$$L = \frac{\mu_0 N^2 A}{l}$$

If the coil is wound over a material of high relative magnetic permeability ur (e.g., soft iron), then

$$L = \mu_r \mu_0 n^2 lA \frac{\mu_r \mu_0 n^2 lA}{l}$$

Factors on which self-inductance depends. Obviously, the self-inductance of a solenoid depends on its geometry and magnetic permeability of the core material.

1. Number of turns. Larger the number of turns in the solenoid, larger is its self-inductance. $L \propto N^2$
2. Area of cross-section. Larger the area of cross-section of the solenoid, larger is its self-inductance.

   $L \propto A$
3. Permeability of the core material. The self inductance of a solenoid increases μ_r times if it is wound over an iron core of relative permeability μ_r.

OR

Consider a disc of radius R rotating in a transverse magnetic field B with frequency *f* in time period T the disc completes one revolution.

$\therefore$ Change in flux = B × Area swept = $B \times \pi R^2$

$$\text{Induced emf} = \frac{\text{Change flux}}{\text{Time}}$$

$$\varepsilon = \frac{B\pi R^2}{T} = B\pi R^2 f \left[\because \frac{1}{f} = T \right]$$

As $f = \frac{\omega}{2\pi}, \therefore \varepsilon\ B \times \pi R^2 . \frac{\omega}{2\pi} = \frac{1}{2} BR^2 \omega$

29. (i) (c) The majority Charge carriers in n-type semiconductor as holes

(ii) (b) BORON

(iii) (c) p-type semiconductors

(iv) (c) Insulators

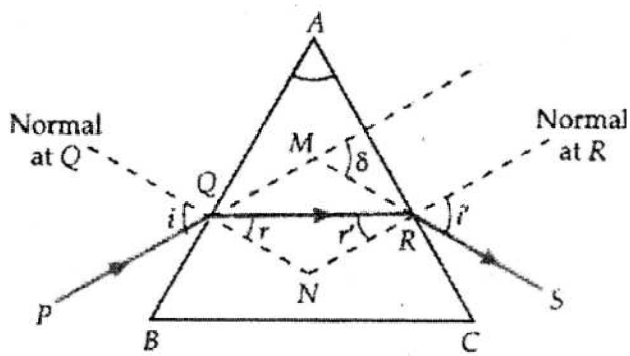
30. (i) (b)

(ii) (c)

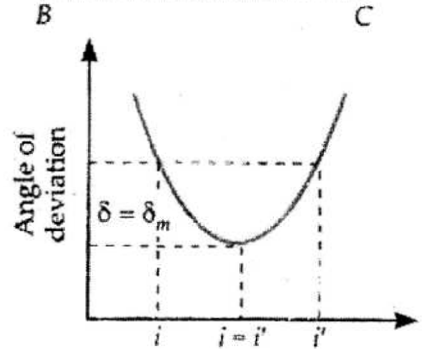
(iii) (c)

(iv) (a)

31. The minimum value of the angle of deviation suffered by a ray on passing through a prism is called the angle of minimum deviation and is denoted by δ_m.



Relation between refractive index and angle of minimum deviation. When a prism is in the position of minimum deviation, a ray of light passes symmetrically (parallel to the base) through the prism so that



$i = i', r = r', \delta = \delta_m$

As $A + \delta = i + i'$

$\therefore$ A + δm = i + i or I = $\dfrac{A+\delta_m}{2}$

Also A = r + r' = r + r = 2r

$\therefore\ r = \dfrac{A}{2}$

From Snell's law, the refractive index of the material of the prism will be

$$\mu = \frac{\sin i}{\sin r} \text{ or } \mu = \frac{\sin \frac{A+\delta_m}{2}}{\sin \frac{A}{2}}$$

By measuring the values of A and δ_m, with the help of a spectrometer, the refractive index μ of the prism glass can be determined accurately.

OR

(i) Intensity at any point of an interference pattern is given by

$I = 2I_0 (1 + \cos \phi)$

where I_0 is the intensity of either wave.

Here $\phi_P = 0$,

$$\phi_P = \frac{2\pi P}{\lambda} = \frac{2\pi}{\lambda}.\frac{\lambda}{4} = \frac{\pi}{2}$$

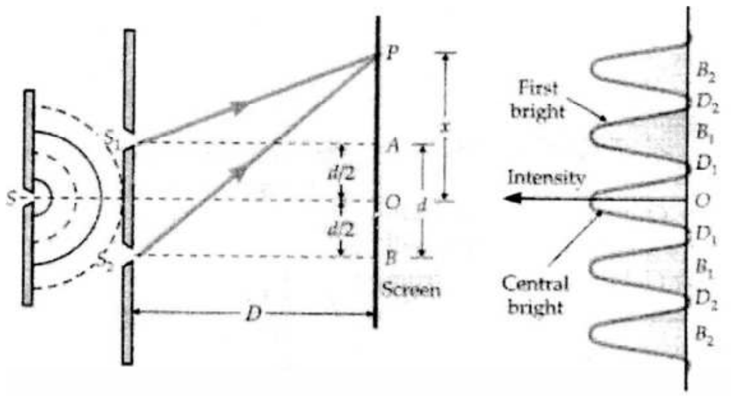
$$\therefore \frac{I_p}{I_Q} = \frac{1 + \cos\phi_P}{1 + \cos\phi_Q} = \frac{1+\cos 0}{1+\cos \pi/2} = \frac{1+1}{1+0} = \frac{2}{1} = 2:1$$

(ii) Derivation of fringe width

Consider a point P on the screen at distance × from the centre O. The nature of the interference at the point P depends on path difference,

$p = S_2P - S_1P$

From right-angled ΔS_2BP and ΔS_1AP, $S_2P^2 - S_1P^2 = [S_2B^2 + PB^2] - [S_1A^2 + PA^2]$



$$= \left[D^2 + \left(x + \frac{d}{2}\right)^2\right] - \left[D^2 + \left(x - \frac{d}{2}\right)^2\right]$$

32. $(S_2P - S_1P)(S_2P + S_1P) = 2\ xd$

or $S_2P – S_1P = \dfrac{2xd}{s_2P + S_1P}$

In practice, the point P lies very close to 0, therefore

$S_1P \approx S_2P \approx D$. Hence

$p = S_2P - S_1P = \dfrac{2xd}{2D}$

or $p = \dfrac{xd}{D}$

Positions of bright fringes. For- constructive interference,

$$P = \frac{dx}{D} = n\lambda$$

or $x = \dfrac{nD\lambda}{d}$ where n = 0, 1, 2, 3, Clearly, the positions of various bright fringes are as follows:

For $n = 0$, $x_0 = 0$ Central bright fringe

For $n = 1$, $x_1 = \dfrac{D\lambda}{d}$ First bright fringe

For $n = 2$, $x_2 = \dfrac{2D\lambda}{d}$ Second bright fringe

For $n = n$, $x_n = \dfrac{nD\lambda}{d}$ n^{th} bright fringe

Positions of dark fringes. For destructive interference,

$$P = \frac{dx}{D} = (2n-1)\frac{\lambda}{2}$$

or $x = (2n-1)\dfrac{D\lambda}{2d}$ where $n = 1, 2, 3.....$

Clearly, the positions of various dark fringes are as follows :

For $n = 1$, $x_1' = \dfrac{1}{2}\dfrac{D\lambda}{d}$ First dark fringe

For $n = 2$, $x_2' = \dfrac{3}{2}\dfrac{D\lambda}{d}$ Second dark fringe

For $n = n$, $x_n' = (2n-1)\dfrac{D\lambda}{2d}$ nth dark fringe

Since the central point O is equidistant from S_1 and S_2, the path difference p for it is zero. There will be a bright fringe at the centre O. But as we move from O upwards or downwards, alternate dark and bright fringes are formed.

Fringe width. It is the separation between two successive bright or dark fringes, Width of a dark fringe = Separation between two consecutive bright fringes

$$x_n - x_{n-1} = \frac{nD\lambda}{d} - \frac{(n-1)D\lambda}{d} = \frac{D\lambda}{d}$$

Width of a bright fringe

= Separation between two consecutive dark fringes

= $X'_n - x'_{n-1}$

** = $(2n-1)\frac{D\lambda}{2d} - [2(n-1)-1]\frac{D\lambda}{2d} = \frac{D\lambda}{d}$

Clearly, both the bright and dark fringes are of equal width.

Hence the expression for the fringe width in Young's double slit experiment can be written as

$$\beta = \frac{D\lambda}{d}$$

32. (i) Capacitance = $\frac{\text{Charge}}{\text{Potential}}$

the capacitance of a conductor may defined as the charge required to increase the potential of the conductor by unit amount.

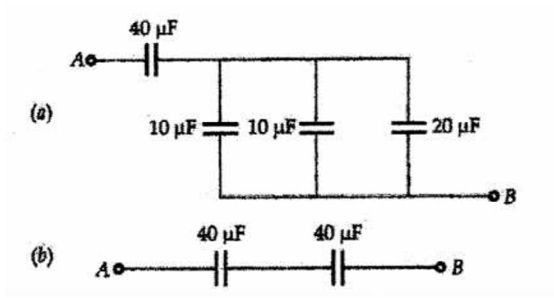
The capacitance of a conductor is the measure of its capacity to hold a large amount of charge without running a high potential. It depends upon the following factors:

Size and shape of the conductor.

Nature (permittivity) of the surrounding medium.

Presence of the other conductors in its neigh-bourhood.

(ii) Here three capacitors of 60 uF each are connected in series. Their equivalent capacitance C_1 is given by



$$\frac{1}{C_1} = \frac{1}{60} + \frac{1}{60} + \frac{1}{60} = \frac{3}{60} = \frac{1}{20}$$

or $\quad C = 20\ \mu F$

The given arrangement now reduces to the equivalent circuit shown.

Clearly, the three capacitors of 10 μF, 10 μF and 20 μF are in parallel. Their equivalent capacitance is

$C_2 = 10 + 10 + 20 = 40\ \mu F$

Now the circuit reduces to the equivalent circuit shown in Fig. 2.60(b). We have two capacitors of 40 μF each connected in series. The equivalent capacitance between A and B is

$$C = \frac{40 \times 40}{40 + 40} = 20\mu F$$

Given V= 100 V

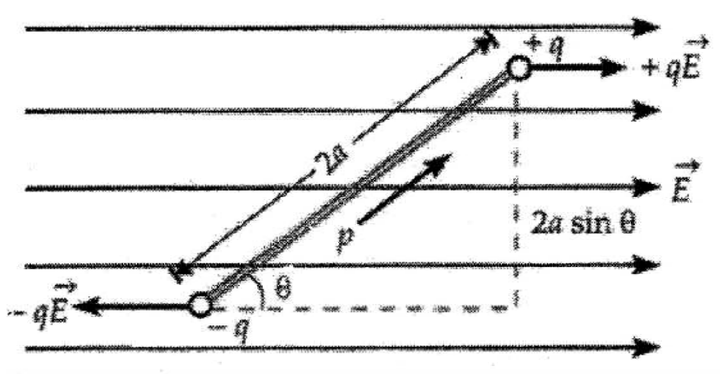
$\therefore$ Charge, $q = CV = 20\ \mu F \times 100\ V = 2000\ \mu C = 2\ mC$

OR

(i) Two equal and opposite forces $+q\vec{E}$ and $-q\vec{E}$ act on its two ends. The two forces form a couple. The torque exerted by the couple will be

$\tau = qE \times 2\,a \sin\theta = pE \sin\theta$

where $q \times 2a = p$, is the dipole moment.



If the dipole is rotated through a small angle dθ against the torque acting on it, then the small work done is $dW = \tau\, d\theta = pE \sin\theta\, d\theta$

The total work done in rotating the dipole from its orientation making an angle θ_1, with the direction of the field to θ_2 will be

$$W = \int dW = \int_{\theta_1}^{\theta_2} \mathrm{pE}\sin\theta d\theta = \mathrm{pE}[-\cos]_1^2 = \mathrm{pE}(\cos\theta_1 - \cos\theta_2)$$

This work done is stored as the potential energy U of the dipole.

$$\mathrm{U} = \mathrm{pE}(\cos\theta_1 - \cos\theta_2)$$

If initially the dipole is oriented perpendicular to the direction of the field ($\theta_1 = 90°$) and then brought to some orientation making an angle θ with the field ($\theta_2 = \theta$), then potential energy of the dipole will be

$\mathrm{U} = \mathrm{pE}\ (\cos 90° - \cos\theta) = \mathrm{pE}\ (0 - \cos\theta)$

or $\mathrm{U} = -\mathrm{pE}\cos\theta = \vec{\mathrm{P}}\,.\,\vec{\mathrm{E}}$

Special Cases

1. Position of stable equilibrium.

   When $\theta - 0°$, $\mathrm{U} = -\mathrm{pE}\cos 0° = -\mathrm{pE}$

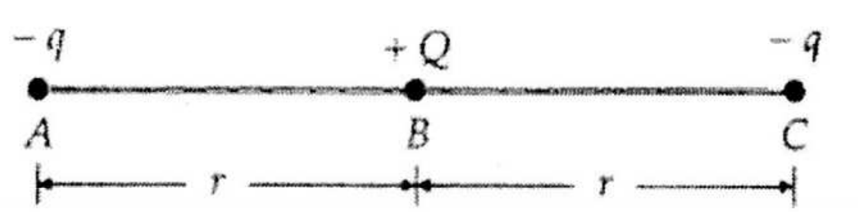
2. Position of zero energy. When $\theta = 90°$,

   $\mathrm{U} = -\mathrm{pE}\cos 90° = 0$.

3. Position of unstable equilibrium. When $\theta = 180°$,

   $\mathrm{U} = -\mathrm{pE}\cos 180° = +\mathrm{pE}$

(ii) suppose the three charges are placed at points A, B and C respectively on a straight line, such that AB = BC = r.



As the total P.E. of the system is zero, so

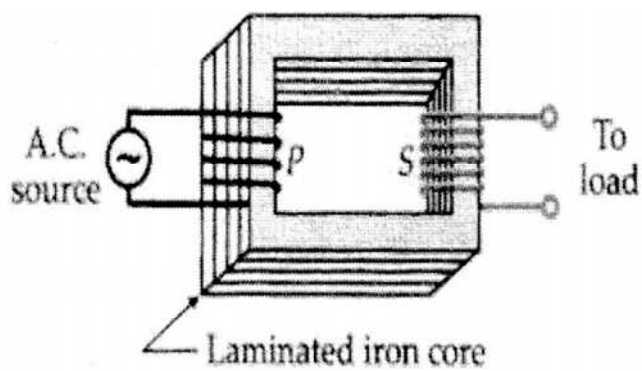
$$\frac{1}{4\pi\varepsilon_0}\left[\frac{-qQ}{r}+\frac{(-q)(-q)}{2r}+\frac{Q(-q)}{r}\right]=0$$

$$-Q+\frac{q}{2}-Q=0 \text{ or } 2Q=\frac{q}{2} \text{ or}$$

$$\frac{Q}{d}=\frac{1}{4}=1:4.$$

33. (i) A transformer is an electrical device for converting an alternating current at low voltage into that at high voltage or vice versa.

Principle. It works on the principle of mutual induction, i.e., when a changing current is passed through one of the two inductively coupled coils, an induced emf is set up in the other coil.



(ii) **(any two)**

1. Copper loss. Some energy is lost due to heating of copper wires used in the primary and secondary windings. This power loss (= l2R) can be minimised by using thick copper wires of low resistance.
2. Eddy current loss. The alternating magnetic flux induces eddy currents in the iron core which leads to some energy loss in the form of heat. This loss can be reduced by using laminated iron core.

3. Hysteresis loss. The alternating current carries the iron core through cycles of magnetisation and demagnetisation. Work is done in each of these cycles and is lost as heat. This is called hysteresis loss and can be minimised by using core material having narrow hysteresis loop.

4. Flux leakage. The magneto flux produced by the primary may not hilly pass through the secondary. Some of the flux may leak into air. This loss can be minimised by winding the primary and secondary coils over one another.

5. Humming loss. As the transformer works, its core lengthens and shortens during each cycle of the alternating voltage due to a phenomenon called magnetostriction. This gives rise to a humming sound. So some of the electrical energy is lost in the form of humming sound.

(iii) Here $N_1 = 100, \varepsilon_1 = 220V, P_1 = 1100\,W$

(a) Transformation ratio, $k = \frac{N_2}{N_1} = 100$

$\therefore\ N_2 = 100N_1 = 100 \times 100 = 10,000$

(b) $I_1 = \frac{P_1}{\varepsilon_1} = \frac{1100}{220} = 5\text{A}$

OR

(i) Resonance condition of a series LCR-circuit. A series LCR-circuit is said to be in the resonance condition when the current through it has its maximum value.

The current amplitude l0 for a series LCR-circuit is given by

$$I_0 = \frac{\varepsilon_0}{\sqrt{R^2 + \left(\omega L - \frac{I}{\omega C}\right)^2}}$$

Clearly, 1_0 becomes zero both for $\omega \to 0$ and $\omega \to \infty$. The value of 1_0 is maximum when $\omega L - \frac{1}{\omega C} = 0$ or $\omega = \frac{1}{\sqrt{\text{LC}}}$

Then impedance, $Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)} = R$

Cleariy the impedance is minimum. The circuit is purely resistive. The current andI voltage are in the same Dhase and the current in the circuit is maximum. This condition of the LCR-circuit s called resonance condition. The frequency at which the current amplitude l,, attains a peak value, s called natural or resonant frequency of the LCR-circuit and is denoted by f_r,

Thus $\omega_r = 2\pi f_r = \frac{1}{\sqrt{LC}}$ or $f_r = \frac{1}{2\pi\sqrt{LC}}$

The current amplitude at resonant frequency will be $I_0 = \frac{\varepsilon_0}{R}$

(ii) Here $R = 50\Omega, L = \frac{20}{\pi} H$,

$$C = \frac{5}{\pi}\mu F = \frac{5}{\pi} \times 10^{-6} F, \varepsilon_{eff} = 230V, f = 50Hz$$

$$X_L = 2\pi f\ L = \frac{20}{\pi} \times 2 \times \pi 50 = 2000\Omega$$

$$X_C = \frac{1}{c \times 2\pi f} = \frac{1}{(5/\pi) \times 10^{-6} \times 2 \times \pi \times 50} = 2000\Omega$$

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

$$= \sqrt{(50)^2 + (2000 - 2000)^2}$$

$$= \sqrt{2500}\Omega = 50\Omega$$

(iii) Impedance of the circuit is

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{45^2 + (4-4)^2} = 45\Omega$$

Reading; of the ammeter $= l_{rms} = \dfrac{\varepsilon_{rms}}{z} = \dfrac{90}{45} = 2A$

Reading of the voltmeter

$= (X_L - X_C)l_{rms} = (4-4) \times 2 = 0$

PRACTICE QUESTION PAPER(SOLVD)

SUBJECT: PHYSICS (THEORY)

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

General Instructions:

Same as practice question paper (Solved)

SECTION-A

1. Electro static potential at any point 'x' is given by $v = -3x^2$. Electric field at a point 'A' whoes coordinates are (1, 0, 0) m, is

   (a) –6 N/C (b) 6 N/C

   (c) –3N/c (d) 3N/C

2. An electric dipole placed in a uniform electric field experiences a torque of $20\sqrt{3}$ Nm. If its potential energy is –60J, the angle dipole makes with electric field is—

   (a) 45° (b) 60°

   (c) 30° (d) 90°

3. Which of the following metals will show photolectric effect when illuminated by visible light-

   (a) Caesium (b) Sodium

   (c) Potassium (d) All the three

4. The shortest wave length present in the Paschen series of spectral lines is—

   (R = Rydberg's constant)

   (a) $\frac{144}{7R}$ (b) $\frac{9}{R}$

   (c) $\frac{4}{R}$ (d) $\frac{36}{5R}$

5. An electron moving with Kinetic energy 'K' in a region of uniform magnetic field 'B'. If magnitude of magnetis field in doubled, then new KE will be

   (a) 2K (b) K

   (c) k/2 (d) 4K

6. The magnetic susceplibibly of a magnetic material has some positive value. The material can be—

   (a) Diamagnetic (b) Paramagnetic

   (c) Ferromagnetic (d) Both paramagnetic and ferromagnetic

7. A galnometer of resistance 'G' is converted into an ammeter of resistance 'R'. The shunt used has a resistance 'S' given by

   (a) S = G + R

   (b) S = R – G

   (c) S = $\frac{RG}{G-R}$

   (d) S = $\frac{RG}{G+R}$

8. Which of the following is NOT true for magnetic field lines-

   (a) Magentic lines can not intersect each other

   (b) Magnetic lines never form on closed loop

   (c) Meghetic lines are more crowded in a region of strong magnetic field

   (d) All are incorrect

9. Transformation ratio of an ideal tramsformer is less than one, then—

   (a) Current flowing in primary coil is more than current in secondary coil

   (b) Current flowing in primary coil is less than current in secondary coil

   (c) Input power is loss than output power

   (d) Input voltage is less than output voltage

10. Electromagnetic waves are produced by—

   (a) Static charge only

   (b) a charge moving with constant speed only

   (c) both (a) and (b)

   (d) an acceleratign charge only

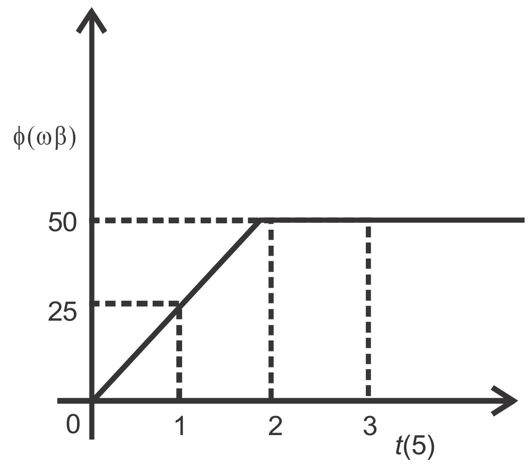
11. In a coil, emf is induced by changing magnetic flux through it. The Variation of magnetic flux with time is shown in the given graph. The emf induced in the coil at t = 1*s* is

(a) –25V

(b) –50V

(c) –100V

(d) –150V



12. An electron revolving in the ground state of hydrogne atom has de-Broglic wavelenth 'λ'. When electron makes a transition to second excited state, its deBroglie wavelength would be—

(a) 2λ (b) 3λ

(c) λ (d) 4λ

For questions 13 to 16, two statemetns are given – one labelled.

Assortion (A) and other labelled Reason (R). Select the current answer to these questions from the options as given below—

(a) If both Assortion and Reason are true and reason is correct explanation of Assertion

(b) If both Assertion and Reason are true and reason in NOT the correct explanation of Assertion

(c) If Assertion is true but reason is false

(d) If both Assertion and Reason are false

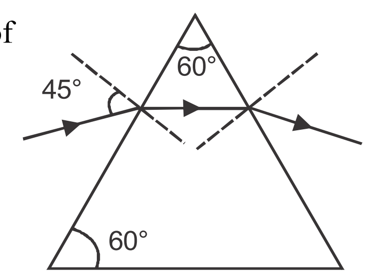
13. Assertion: All the photo electrons emitted from a metal surface during photo electric effect do not have same energy.

Reason : The Kinetic energy of photo electrons doesnot depend on the intensity of radiation incidenting on the metal surface.

14. Assertion : Carbon, Silicon and Germenium have same lattie structure yet carbon is insulator but Silicon and germanium are intrinsic semiconductor.
Reason : The 4-bonding electrons of carbon are more tightly bound to nucleus than in silicon and germenium atom.
15. Assertion : Electro static force between two given charges kept at given distance is maximum in vacuum.
Reason : The dielectric constant of vaccum has maximum value.
16. Assertion : Focal length of a concave mirror is increased when air is replaced by water.
Reason : The speed of light is increased when travels from air into water.

SECTION-B

17. Explain formation of deplation region in a *p-n* junction.
18. Photoemission occurs when a surface is irradrated with the radiation of frequency v_1 and v_2. The maximum KE of electrons emitted for two frequencies are K and 2K respectively obtain expression of threshold frequency.
19. A ray of light is incident on a prism at an angle of 45^6 and passes symmetrically as shown in figure.



Calcualte-
(i) Angle of minimum deviatien
(ii) Refractive index of prism
20. The temperature coefficient of a resistance wire is 0.00125 $°C^{-1}$. At 300K, its resistance is 1 Ω. At what temperature the resistance of the wire will be 2Ω?
21. Modern telescopes use a concave mirror rather than a lens for objective. Write two reasons.

OR

A compound microscope consits of an objective and eye piece. The magnification produced by the microscope is 250. If magnification produced by objective is 20, calcalate focal length of eye-peice when final image in formed at infinily.

SECTION-C

22. In a fission event of $_{92}U^{238}$ by fast moving neutrons, no neutrons are emitted and final products are $_{58}Ce^{140}$ and $_{44}Ru^{99}$ after some decay process. Calculate Q-value for this process neglectingthe masses of electron & positron emitted during intermediate steps.

Given - $m\left({}_{92}U^{238}\right) = 238.05079u; m\left({}_{58}Ce^{140}\right) = 139.90543\ u$

$m\left({}_{44}Ru^{99}\right) = 98.90594u; m\left({}_{0}n^{1}\right) = 1.008665\ u$

Deuterium undergoes fusion reaction as shown—

$_1H^2 + {}_1H^2 \longrightarrow {}_2He^3 + {}_0n^1 + 2.27MeV$

Find the duration for which an electric-bulb of 500W can be kept glowing by fusion of 100 g of deuterium.

23. (a) Two point charges $+Q_1$ and $-Q_2$ are placed L distance apart, obtian an expression for work done in bringing a third charge Q_3 from infinity to the mid point of line joining two charges.

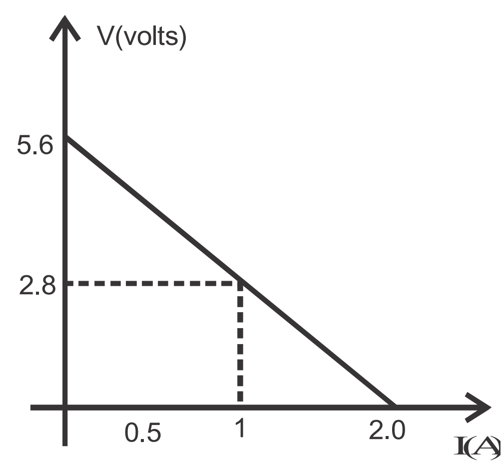
(b) At what distance from charge Q_1 on the line joining two charges will this work done be zero?

24. In Geiger-Marsdon experimetn, calculate the distance of closest approach for an α-particel with energy 2.56×10^{-12}J. Consider that α-particle approaches gold nucleus (z = 79) in head on position.

25. 4 cells of identical emf 'ε', internal resitance 'r', are connected in series to variable resistor. The foloowing graph shows the variation of terminal voltage of combination with current output.

(i) What is emf of each cell used?

(ii) What in internal resistance of each cell?



26. I. Draw a lebelled diagram of movign coil galenometer. Write its working primuple and show that the scale of moving coil galvenometer is linear.

OR

Using Biot-Sarat law, deduce expression for magnetic field due to a current carrying circular coil at any point on its axis.

27. Identify electronmagnetic waves which—

(i) are used in radar system

(ii) affect a photographic plate

(iii) are used in surgery

Write their frequency range

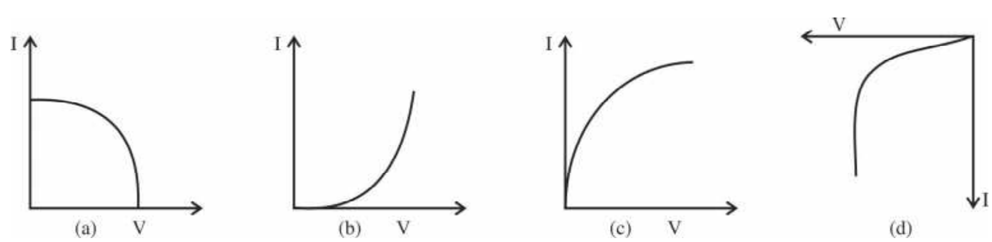
28. Define self inductance and write its SI unit. Mention the factors affecting self inductance of a long solenoid.

SECTION-D

29. Read the passage given below and answer questions that follow:

A semiconductor doide is basically a p-n junction with metallic contacts provided at ends for the application of external voltage. Applying some external voltage across the diode is called biasing. The two types of biasing are forward biasing and reverse biasing. An ideal diode is one which offers zero resistance in forward biasing and infinite resistance in vererse biasing.

I. Which of the following graph represent V-I characteristics of a diode in forward bias—



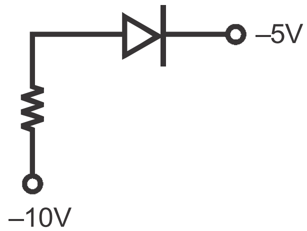
II. When a reverse bias is applied to a *p-n* junction it

(a) raises the potential barrier (b) increases width of deplection layer

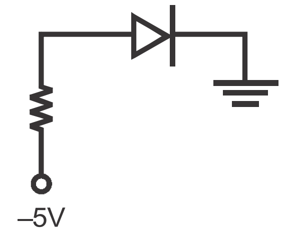
(c) increase junction resistance (d) All these correct

III. In which of following figure, the *p n* function is forward blased?

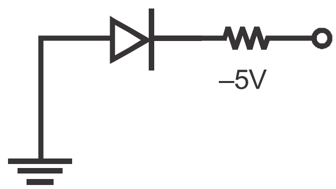
(a)



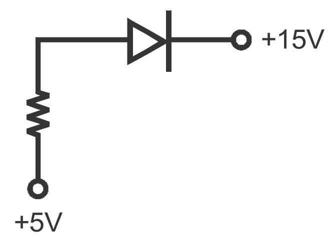
(b)



(c)



(d)



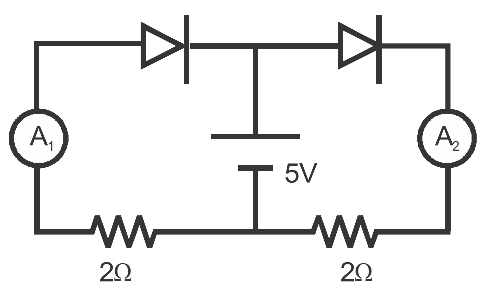
IV. In the given diagram, dcode D_1 and D_2 are idea diodes. Which of the following is correct.

(a) Both the ammeters (A_1) and (A_2) will show deflection

(b) None of the ammders (A_1) and (A_2) will show deflection

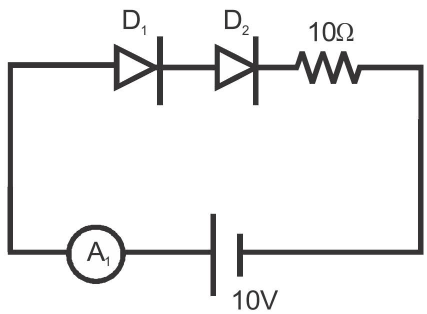
(c) Only ammeter (A_1) will show deflection

(d) Only ammder (A_2) will show the deflection



OR

In the given diagram,diodes D_1 and D_2 are ideal diodes. The ammeter reading (when ammeter used is ideal) is



(a) zero (b) 10A

(c) 100 A (d) 1A

30. Read the paragraph given below and answer questions that follows Lens is a transparent medium bunded by two refracting surfaces, at least one of which must be spherical surface. The focal length of a lens is determined by its radii of curvature and refractive index of lens and surrouding medium. Ability of a lens to converge or diverge beam of light is called power of lens.

I. A point object is placed in air at a distance 'R' in front of a convex spherical refracting surface of radius of curvalce 'R'. If the medium on the other side of surface is glass then the image is-

(a) real and formed in glass

(b) real and formed in air

(c) virtual and formed is glass

(d) virtual and formed is air

II. The focal length of an equiconvey lens is f. When cut into two equal pieces perpenduclar to principal axis the focal lenght of each half is-

(a) f (b) $2f$

(c) $f/2$ (d) $4f$

III. Focal length of a lens in air is 10 cm. When it is immersed in water, the focal lenght will become. ($\mu_L = 3/2$, $\mu_\omega = 4/3$)

(a) 2.5 cm (b) 20 cm

(c) 40 cm (d) 5 cm

IV. Two convex of focal lengths 20 cm and 30 cm are kept in contact. The focal length of combination is-

(a) 60 cm (b) 12 cm

(c) 50 cm (d) 10 cm

OR

Which of the following is ture-

(a) A convey lens is always a converging lens

(b) A concave lens is always a diverging lens

(c) Both (a) and (b)

(d) Neither (a) nor (b)

SECTION-E

31. (a) Mention two essential condtron for total intenal reflection to occur.

(b) Write two uses of total internal reflection

(c) A point source of light is placed at the bottom of a tank filled with water, of refractive index 'n' to a depth 'd'. Find the area of surface of water through which light from source can emerge.

OR

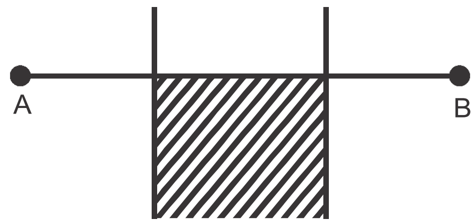
(a) What are cohdent sources of light? How they can be produced?

(b) Using Huygen, principle explain snell Snell's law when light is travelling from denser medium to rarer medium.

32. (a) Obtain expression for capacitance of a parallel plate capacitor.

(b) What is the role of negative plate of the capacitor?

(c) The capacitance of a parallel plate capacitor with vacuum between the plates is 20μF. When half the space between the plates is filled with a medium its capactance becomes 80μF (as shown in figure). Calculate dielectric canstant of the medium.



OR

(a) Discuss limitation of Ohm's law.

(b) Two conductors of different materials are connected in series across d.c. sources. The ratio of their lengths and area of cross section are 1 : 2 and 3 : 2 respectively. What should be the ratio of their electron density such that they have same drift velocity of electrons flowing through them.

33. (a) When an a.c. source $E = E_0 \sin\omega t$ is connected with a resistor R in series with an element 'X', the current in the circuit is found to be $I = I_0 \sin(\omega t + \pi/4)$.

(i) Identify the element 'x' Justifying the answer

(ii) Find the impedance of the circuit

(iii) Calculate the peak current 'I_0' flowing in the circuit

(iv) What change your need to make in the circuit to bring circuit in resonance?

OR

(a) A voctage source $V = V_0 \sin\omega t$ is applied to a series LCR circuit. Derive an expression for average power dissipated over a cycle.

(b) Under what condition-

(i) no power is dissipated even thought the covent flows through the circuit?

(ii) Maximum power dissipated in the circuit.

Answers

1.	(b)	2.	(c)	3.	(d)	4.	(b)
5.	(b)	6.	(d)	7.	(c)	8.	(b)
9.	(a)	10.	(d)	11.	(a)	12.	(b)
13.	(b)	14.	(a)	15.	(c)	16.	(d)
18.	$2v_1 - v_2$	19.	(i) 30° (ii) $\sqrt{2}$			20.	1027 K

21. (i) lesser in weight (ii) free from spherical aberratirium

OR

fe = 2cm

22. 231.1 MeV

23. (a) W = $\dfrac{2K\,(Q_1 - Q_2)Q_3}{L}$ (b) $x = \dfrac{LQ_1}{Q_1 + Q_3}$

24. 1.42×10^{-14} m

25. (i) ε = 1.4 V

(ii) r = 0.7 Ω

29.	(i) (b)	(ii)	(d)	(iii)	(c)	(iv)	(d)
	OR	(d)					
30.	(i) (a)	(ii)	(c)	(iii)	(c)	(iv)	(b)
	OR	(d)					

33. (i) X = capacitor 32. (c) K = 7 OR (b)

2 : 3

(ii) Z = $R\sqrt{2}$

(iii) $I_0 = \dfrac{E_0}{R\sqrt{2}}$

(iv) By connecting an inductor such that X_L = R

OR

(b) (i) When R = 0

(ii) Phase angle between current and voltage is zero.

PRACTICE QUESTION PAPER(SOLVD)

SUBJECT: PHYSICS (THEORY)

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

General Instructions:

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

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

(3) All the sections are compulsory.

(4) Section A contains sixteen questions, twelve MCQ and four Asser Reasoning based of 1 mark each, Section B contains five questions of two marks each, Section C contains seven questions of three marks each, Section D contains two case study based question four marks each and Section E contains three long arts questions of five marks each.

(5) There is no overall choice. However, an internal choice has b provided in one question in Section B, one question in Section C. question in each CBQ in Section D and all three questions in Sec E. You have to attempt only one of the choices in such question

(6) Use of calculators is not allowed.

(7) You may use the following values of physical constants w necessary

(i) c = 3 × 108m/s

(ii) $m_e = 9.1 \times 10^{-31}$ kg

(iii) $e = 1.6 \times 10^{-19}$ C

(iv) $\mu_0 = 4n \times 10^{-7}$ TmA^{-1}

(v) $h = 6.63 \times 10^{-34}$ Js

(vi) $\varepsilon_0 = 8.854 \times 10^{-12}$ $C^2N^{-1}m^{-2}$

(vii) Avogadro's number = 6.023×10^{23} per gram mole

SECTION-A

1. Which of the following is not the property of an equipotential surface?

(a) They do not cross each other.

(b) The work done in carrying a charge from one point to another on an equipotential surface is zero.

(c) For a uniform electric field, they are concentric spheres,

(d) They can be imaginary spheres.

2. An electric dipole placed in an electric field of intensity 2×10^5 N/C at an angle of 30° experiences a torque equal to 4 Nm. The charge on the dipole of dipole length 2 cm is

   (a) 7 μC (b) 8 mC

   (c) 2 mC (d) 5 mC

3. A metallic plate exposed to white light emits electrons. For which of the following colours of light, the stopping potential will be maximum?

   (a) Blue (b) Yellow

   (c) Red (d) Violet

4. When alpha particles are sent through a thin gold foil, most of them go straight through the foil, because

   (a) alpha particles are positively charged

   (b) the mass of an alpha particle is more than the mass of an electron

   (c) most of the part of an atom is empty space

   (d) alpha particles move with high velocity

5. An electron is moving along positive x-axis in a magnetic field which is parallel to the positive y-axis. In what direction will the magnetic force be acting on the electron?

   (a) Along -x axis (b) Along -z axis

   (c) Along +z axis (d) Along -y axis

6. The relative permeability of a substance X is slightly less than unity and that of substance Y is slightly more than unity, then

   (a) X is paramagnetic and Y is ferromagnetic

   (b) X is diamagnetic and Y is ferromagnetic

   (c) X and Y both are paramagnetic

   (d) X is diamagnetic and Y is paramagnetic

7. An ammeter of resistance 0.81 ohm reads up to 1 A. The value of the required shunt to increase the range to 10 A is

   (a) 0.9 ohm (b) 0.09 ohm

   (c) 0.03 ohm (d) 0.3 ohm

8. An electron with angular momentum L moving around the nucleus has a magnetic moment given by

(a) eL/2m (b) e L/3m

(c) e L/4m (d) eL/m

9. The large scale transmission of electrical energy over long distances is done with the use of transformers. The voltage output of the generator is stepped-up because of

(a) reduction of current (b) reduction of current and voltage both

(c) power loss is cut down (d) (a) and (c) both

10. The diagram below shows the electric field (E) and magnetic field (B) components of an electromagnetic wave at a certain time and location.

The direction of the propagation of the electromagnetic wave is

(a) perpendicular to E and B and out of plane of the paper

(b) perpendicular to E and B and into the plane of the paper

(c) parallel and in the same direction as E

(d) parallel and in the same direction as B

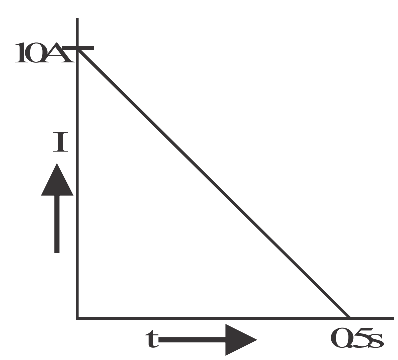
11. In a coil of resistance 100 Ω a current is induced by changing the magnetic flux through it. The variation of current with time is as shown in the figure. The magnitude of change in flux through coil is

(a) 200 Wb

(b) 275 Wb

(c) 225 Wb

(c) 250 Wb



12. The energy of an electron in nth orbit of hydrogen atom $E_n = \frac{-13.6}{n^2} eV$ negative sign of energy indicates that

(a) electron is free to move.

(b) electron is bound to the nucleus.

(c) kinetic energy of electron is equal to potentic

(d) atom is radiating energy.

For Questions 13 to 16, two statements are given-one labelled Assertion (A) and other labelled Reason (R). Select the correct answer to these questions from the options as

(a) If both Assertion and Reason-are true and Reason is correct explanation of Assertion.

(b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

(c) If Assertion is true but Reason is false.

(d) If both Assertion and Reason are false.

13. Assertion (A): For the radiation of a frequency greater than the threshold frequency, photoelectric current is proportional to the intensity of the radiation.

Reason (R) : Greater the number of energy quanta available, greater is the number of electrons absorbing the energy quanta and greater is number of electrons corning out of the metal.

14. Assertion (A) : Putting p type semiconductor slab directly in physical contact with *n* type semiconductor slab cannot form the *pn* junction

Reason (R) : The roughness at contact will be much more than inter atomic crystal spacing and continuous flow of charge carriers is not possible.

15. Assertion (A) : An electron has a higher potential energy when it is at a location associated with a negative value of potential and has a lower potential energy when at a location associated with a positive potential.

Reason (R) : Electrons move from a region of higher potential to a region of lower potential.

16. Assertion (A) : Propagation of light through an optical fibre is due to total internal reflection taking place ai the core-cladding interface.

Reason (R) : Refractive index of the material of the cladding of the optical fibre is greater than that of the core.

SECTION-B

17. (a) Name the device which utilizes unilateral action of a *pn* diode to convert ac into *dc*.

(b) Draw the circuit diagram of full wave rectifier.

18. The wavelength A of a photon and the de Broglie wavelength of an electron of mass *m* have the same value. Show that the energy of the photon is $2\lambda mc/h$ times the kinetic energy of the electron, where c and h have their usual meanings.

19. A ray of monochromatic light passes through an equilateral glass prism in such a way that the angle of incidence is equal to the angle of emergence and each of these angles is 3/4 times the angle of the prism. Determine the angle of deviation and the refractive index of the glass prism.

20. A heating element using nichrome connected to a 230 V supply draws an initial current of 3.2 A which settles after a few seconds to a steady value of 2.8 A. What is the steady temperature of the heating element if the room temperature is 27.0 °C and the temperature coefficient of resistance of nichrome is $1.70 \times 10^{-4}\ °C^{-1}$?

21. Show that the least possible distance between an object and its real image in a convex lens is 4*f*, where f is the focal length of the lens.

OR

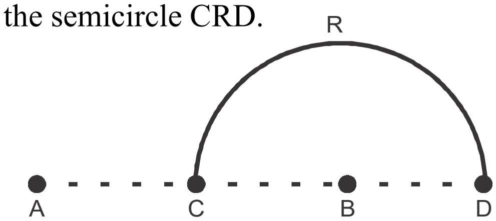
In an astronomical telescope in normal adjustment a straight black line of length L is drawn on the objective lens. The eyepiece forms a real image of this line whose length is *l*. What is the angular magnification of the telescope?

SECTION-C

22. A given coin has a mass of 3.0 g. Calculate the nuclear energy that would be required to separate all the neutrons and protons from each other. For simplicity assume that the coin is entirely made of $^{63}_{29}Cu$ atoms (of mass 62.92960 u).

Given m_P = 1.007825u and m_n = 1.008665u.

23. Charges (+q) and (–q) are placed at the points A and B respectively which are a distance 2L apart. C is the midpoint between A and B. What is the work done in moving a charge +Q along the semicircle CRD.



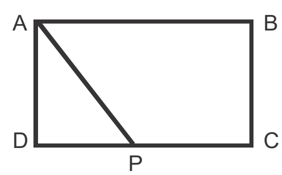
24. The total energy of an electron in the first excited state of the hydrogen atom is about –3.4 eV.

    (a) What is the kinetic energy of the electron in this state?

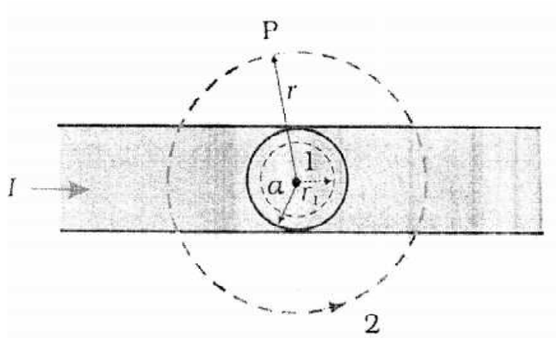
    (b) What is the potential energy of the electron in this state?

    (c) Which of the answers above would change if the choice of the zero of potential energy is changed?

25. A wire of uniform cross-section and resistance 4 ohm is bent in the shape of square ABCD. Point A is connected to a point P on DC by a wire AP of resistance 1 ohm. When a potential difference is applied between A and C, the points B and P are seen to be at the same potential. What is the resistance of the part DP?



The given figure shows a long straight wire of a circular cross-section (radius a) carrying steady current *l*. The current *l* is uniformly distributed across this cross-section. Calculate the magnetic field in the region $r < a$ and $r > a$.



27. Identify the part of the electromagnetic spectrum which:

(a) produces heating effect,

(b) is absorbed by the ozone layer in the atmosphere,

(c) is used for studying crystal structure.

Write any one method of the production of each of the above radiations.

28. (a) Define mutual inductance and write its SI unit.

(b) Two circular loops, one of small radius rand other of larger radius R, such that R >> *r*, are placed coaxially with centres coinciding. Obtain the mutual inductance of the arrangement.

OR

Two long straight parallel current carrying conductors are kept 'a' distant apart in air. The direction of current in both the conductors is same. Find the magnitude of force per unit length and direction of the force between them. Hence define one ampere.

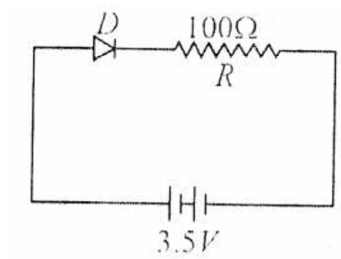
SECTION-D

Case Study Based Questions

29. **Read the following paragraph and answer the questions that follow.**

A semiconductor diode is basically a pn junction with metallic contacts provided at the ends for the application of an external voltage. It is a two terminal device. When an external voltage is applied across a semiconductor diode such that p-side is connected to the positive terminal of the battery and n-side to the negative terminal, it is said to be forward biased. When an external voltage is applied across the diode such that n-side is positive and p-side is negative, it is said to be reverse biased. An ideal diode is one whose resistance in forward biasing is zero and the resistance is infinite in reverse biasing. When the diode is forward biased, it is found that beyond forward voltage called knee voltage, the conductivity is very high. When the biasing voltage is more than the knee voltage the potential barrier is overcome and the current increases rapidly with increase in forward voltage. When the diode is reverse biased, the reverse bias voltage produces a very small current about a few microamperes which almost remains constant with bias. This small current is reverse saturation current.

(i) In the given figure, a diode D is connected to an external resistance R = 100 Ω and an ernf of 3.5 *V*. If the barrier potential developed across the diode is 0.5 *V*. the current in the circuit will be:

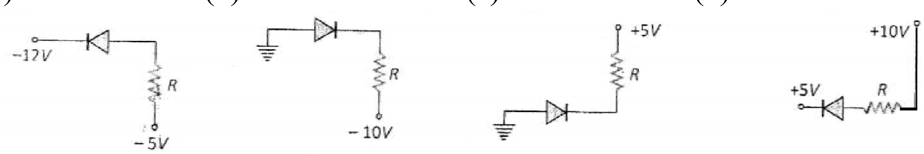


(a) 40 mA (b) 20 mA

(c) 35 mA (d) 30 mA

(ii) In which of the following figures, the pn diode is reverse biased?

(a) (b) (c) (d)



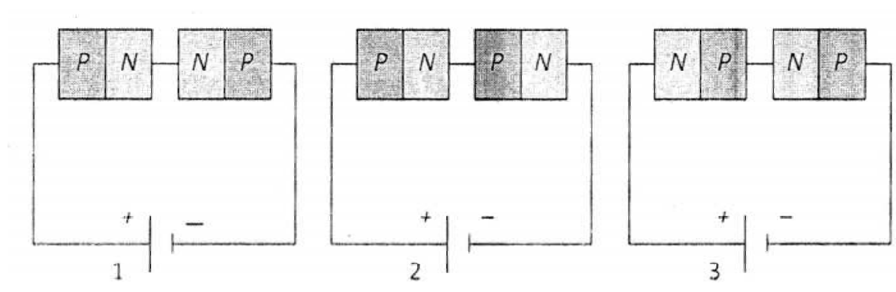
(iii) Based on the V-l characteristics of the diode, we can classify diode as

(a) bilateral device (b) ohmic device

(c) non-ohmic device (d) passive element

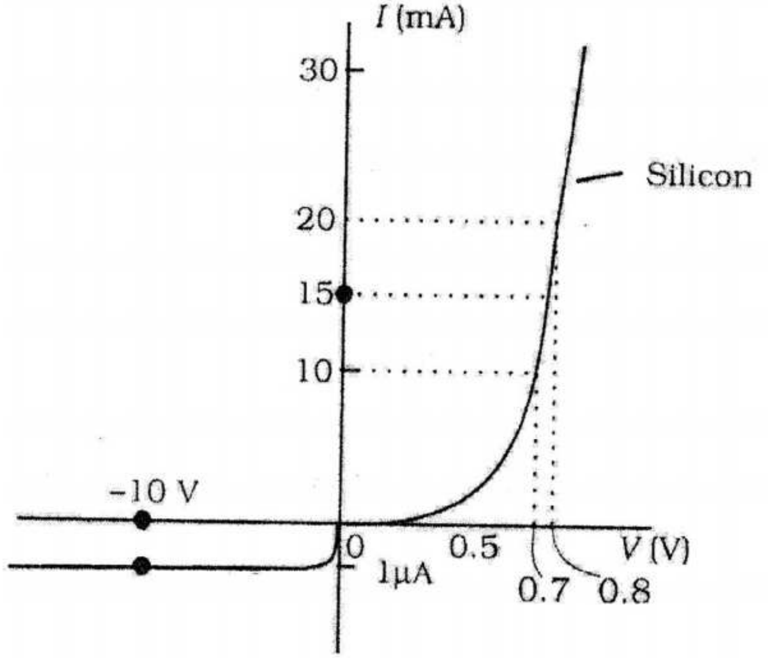
OR

Two identical PN junctions can be connected in series by three different methods as shown in the figure. If the potential difference in the junctions is the same, then the correct connections will be



(a) in the circuits (1) and (2) (b) in the circuits (2) and

(c) in the circuits (1) and (3) (d) only in the circuit (1)



IV.

The V-l characteristic of a diode is shown in the figure. The ratio of the resistance of the diode at I = 15 mA to the resistance at V = –10 V is

(a) 100 (b) 10^6

(c) 10 (d) 10^{-6}:

30. **Read the following paragraph and answer the questions that follow. Types of Lenses and their combination**

A convex or converging lens is thicker at the centre than at the edges. It converges a beam of light on refraction through it. it has a real focus. Convex lens is of three types: Double convex lens, plano convex lens and Concavo-convex lens.

Concave lens is thinner at the centre than at the edges. It diverges a beam of light on refraction through it. It has a virtual focus. Concave lenses are of three types: Double concave lens, plano concave lens and Convexo-concave lens.

When two thin lenses of focal lengths f_1 and f_2 are placed in contact with each other along their common principal axis, then the two lens system is regarded as a single iens of focal length f and

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

If several thin lenses of focal length $f_1, f_2, ... f_n$ are placed in contact, then the effective focal length of the combination is given by

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + ... + \frac{1}{f_n}$$

and in terms of power, we can write

$$P = P_1 + P_2 + ... + P_n$$

The value of focal length and power of a lens must be used with proper sign consideration.

(i) Two thin lenses are kept coaxially in contact with each other and the focal length of the combination is 80 cm. If the focal length of one lens is 20 cm, the focal length of the other would be

(a) -26.7cm (b) 60cm

(c) 80cm (d) 30cm

(ii) A spherical air bubble is embedded in a piece of glass. For a ray of light passing through the bubble, it behaves like a

(a) converging lens

(b) diverging lens

(c) mirror

(d) thin plane sheet of glass

(iii) Lens generally used in magnifying glass is

(a) single concave iens

(b) single convex lens

(c) combination of convex lens of lower power and concave lens of lower focal length

(d) Planoconcave lens

(iv) The magnification of an image by a convex lens is positive only when the object is placed

(a) at its focus F

(b) between F and 2F

(c) at 2F

(d) between F and optical centre

OR

A convex lens of 20 cm focal length forms a real image which is three times magnified. The distance of the object from the lens is

(a) 13.33 cm (b) 14 cm

(c) 26.66 cm (d) 25 cm

SECTION-E

31. (i) Draw a ray diagram for the formation of image of a point object by a thin double convex lens having radii of curvature R_1 and R_2. Hence derive lens maker's formula.

(ii) A converging lens has a focal length of 10 cm in air. It is made of a material of refractive index 1.6. If it is immersed in a liquid of refractive index 1.3, find its new focal length.

OR

(i) Define a wavefront. How is it different from a ray?

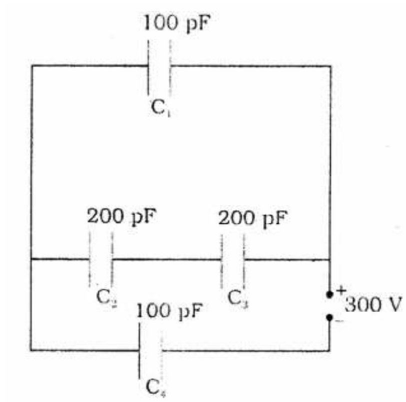
(ii) Using Huygens's construction of secondary wavelets draw a diagram showing the passage of a plane wavefront from a denser to a rarer medium. Using it verify Snell's law.

(iii) In a double slit experiment using light of wavelength 600nm and the angular width of the fringe formed on a distant screen is 0.1°. Find the spacing between the two slits.

(iv) Write two differences between interference pattern and diffraction pattern.

32. (i) Derive an expression for the capacitance of a parallel plate capacitor with air present between the two plates.

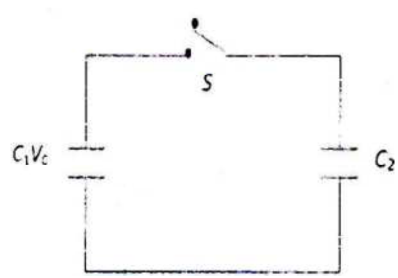
(ii) Obtain the equivalent capacitance of the network shown in figure. For a 300 V supply, determine the charge on each capacitor.



OR

(i) A dielectric slab of thickness 't' is kept between the plates of a parallel plate capacitor with plate separation 'd' (t < d). Derive the expression for the capacitance of the capacitor.

(ii) A capacitor of capacity C, is charged to the potential of V_0. On disconnecting with the battery, it is connected with an uncharged capacitor of capacity C as shown in the adjoining figure. Find the ratio of energies before and after the connection of switch S.



33. (a) Draw graphs showing the variations of inductive reactance and capacitive reactance with frequency of applied ac source.

(b) Draw the phasor diagram for a series LRC circuit connected to an AC source.

(c) When an alternating voltage of 220V is applied across a device X, a current of 0.25A Hows which lags behind the applied voltage in phase by $\pi/2$ radian. If the same voltage is applied across another device Y, the same current flows but now it is in phase with the applied voitage.

(i) Name the devices X and Y.

(ii) Calculate the current flowing in the circuit when the same voltage is applied across the series combination of X and Y.

OR

(a) A series LCR circuit is connected to an ac source. Using the phasor diagram, derive the expression for the impedance of the circuit.

(b) Plot a graph to show the variation of current with frequency of the ac source, explaining the nature of its variation for two different resistances R_1 and R_2 ($R_1 < R_2$) at resonance.