PM SHRI SCHOOLS

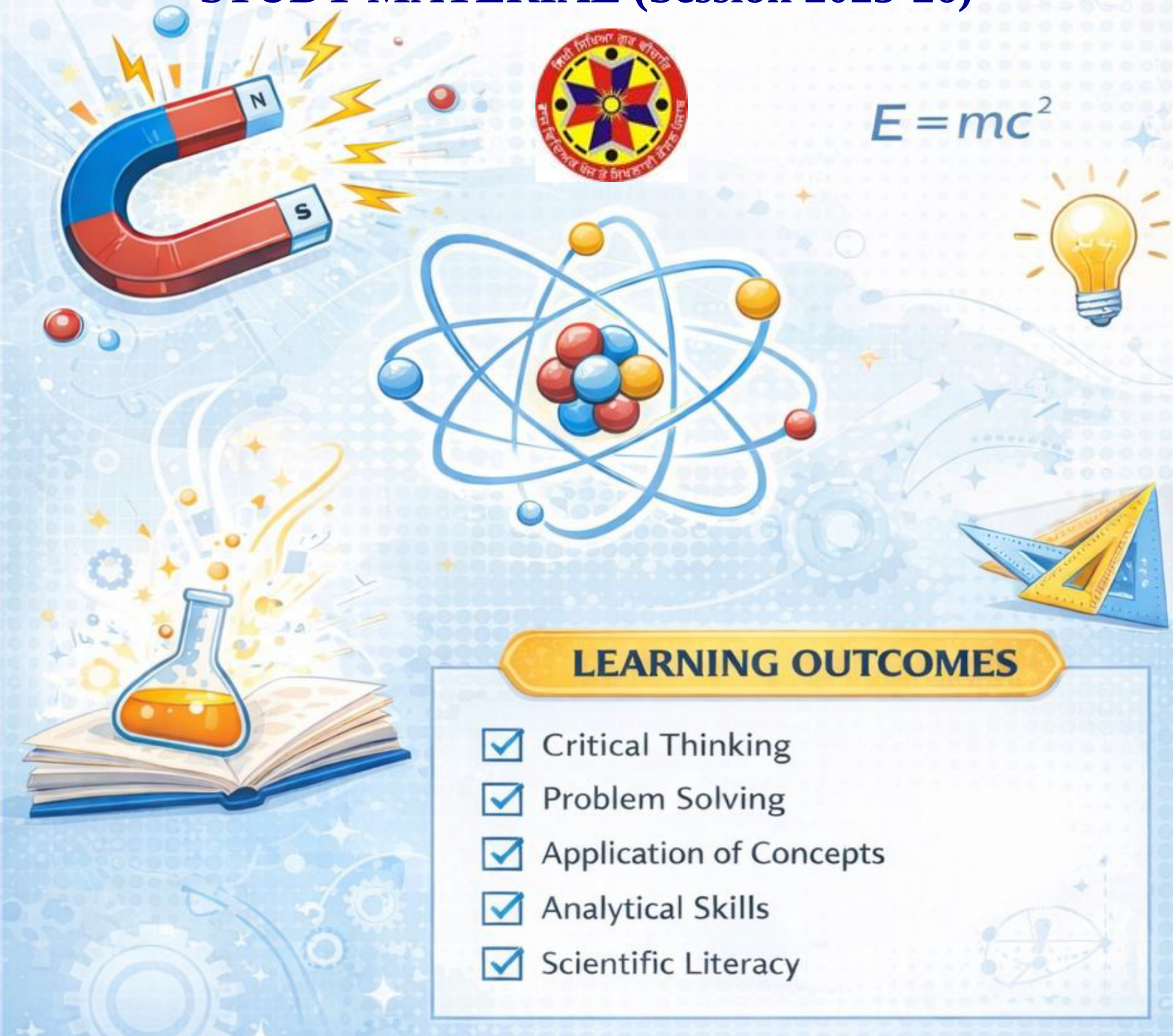
$F = ma$

LEARNING ENHANCEMENT PROGRAM

CLASS: 12th

Subject: Physics (LEP)

STUDY MATERIAL (Session 2025-26)



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*Key points in form of Concept Maps-Annexure A

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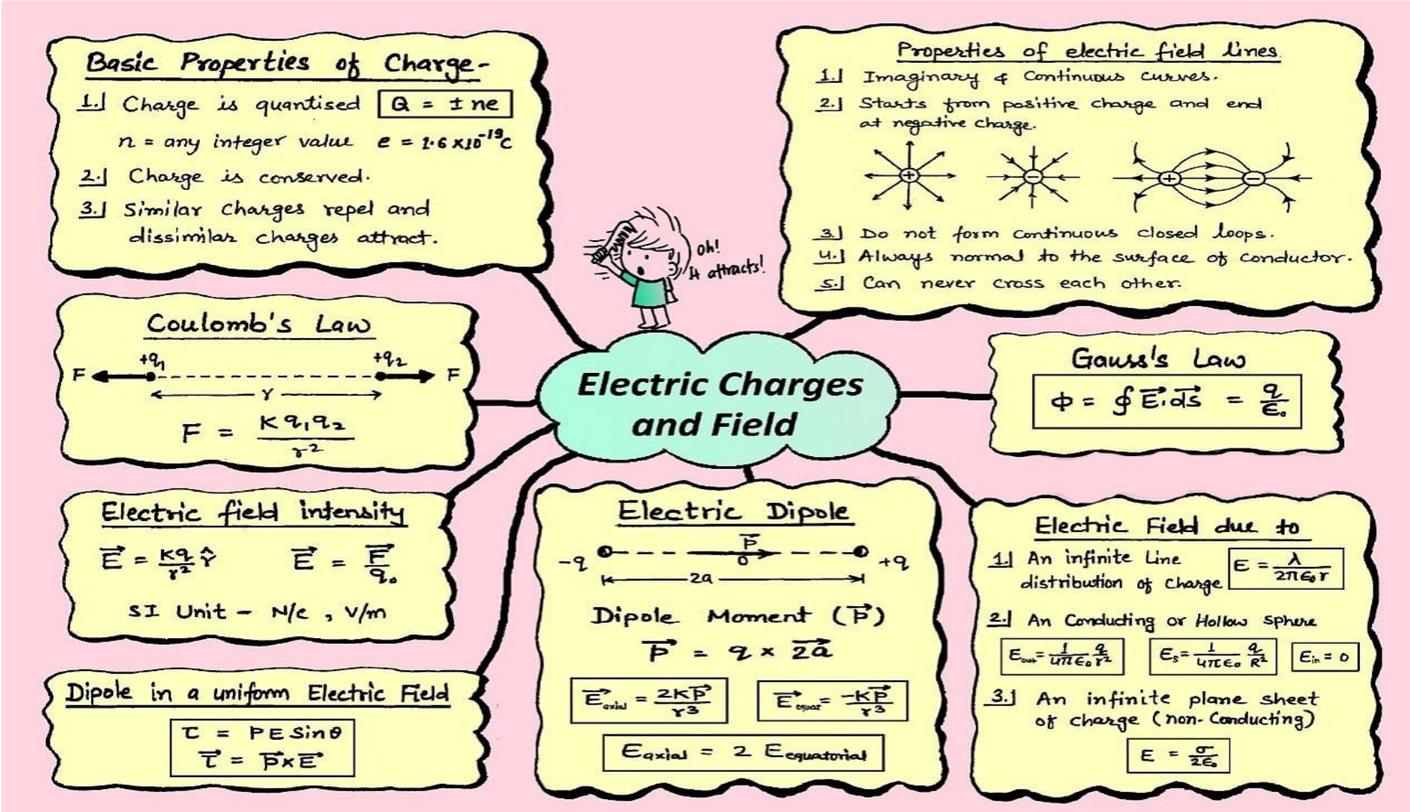
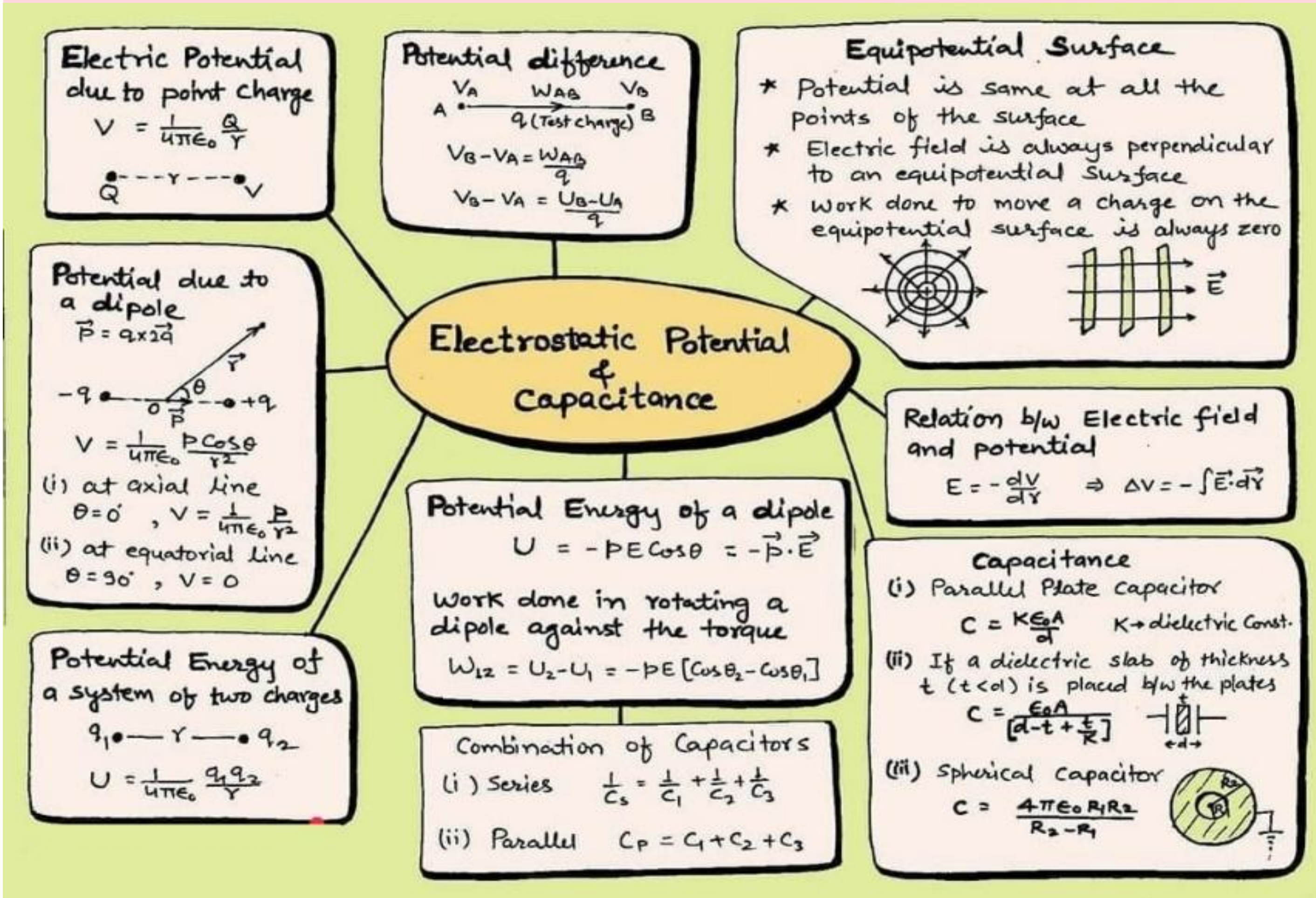
Annexure A

KEY POINTS IN FORM OF CONCEPT MAPS





Current Electricity

Electric Current $I = \frac{q}{t}$

Instantaneous current $I = \frac{dq}{dt}$

SI Unit – Ampere (A)

Current is a scalar quantity.

Ohm's Law

$V = IR$

$R = \frac{\rho l}{A}$

$\rho = \frac{m}{ne^2\tau}$

Variation of Resistivity / Resistance with Temperature

For temperature variation from T_1 to T_2

$R_2 = R_1 [1 + \alpha (T_2 - T_1)]$

Drift Velocity $V_d = \left(\frac{eE}{m}\right)\tau$

$I = neAV_d$

Electrical Power

$P = V \times I = I^2R = \frac{V^2}{R}$

Electrical Energy

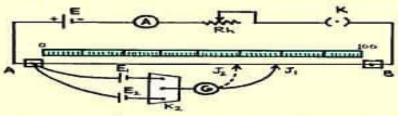
$H = W = I^2Rt = \frac{V^2t}{R}$

Mobility $(\mu) = \frac{V_d}{E}$

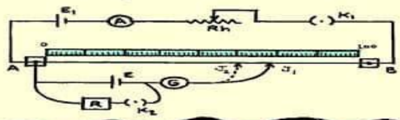
Current Density $(J) = \frac{I}{A}$

Potentiometer

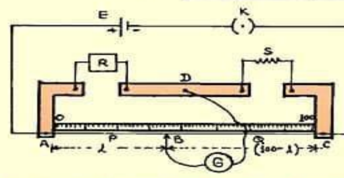
(A) Comparison of EMF's of two cells $\frac{E_1}{E_2} = \frac{l_1}{l_2}$



(B) Determination of internal resistance of the cell $r = \left(\frac{l_1}{l_2} - 1\right)R$



Meter Bridge $S = \left(\frac{100 - l}{l}\right) \times R$



Resistors in series

$R_s = R_1 + R_2 + R_3$

Resistors in parallel

$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

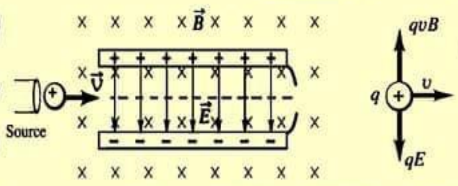
Magnetic Effect of Current

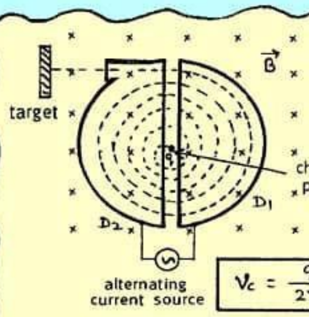
Force on a moving charge in a magnetic field

$F = qVB\sin\theta$

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

Velocity Selector $V = \frac{E}{B}$





$V_c = \frac{qB}{2\pi m}$ cyclotron frequency

$K.E. = \frac{1}{2}mv^2 = \frac{q^2B^2R^2}{2m}$

Magnetic Force on a current Carrying Conductor

$F = ILB\sin\theta$

$\vec{F} = I\vec{l} \times \vec{B}$

Motion in a Magnetic Field

(i) When charge particle moves at angle 90° to field

$r = \frac{mv}{qB}$ $\quad T = \frac{2\pi m}{qB}$

(ii) When charge particle at any angle to the field

$r = \frac{mv\sin\theta}{qB}$ $\quad T = \frac{2\pi m}{qB}$

Pitch $P = \frac{2\pi mv\cos\theta}{qB}$

(iii) When the charged particle is moving at ($\theta = 0$ or 180°) to the magnetic field

$F = 0$ Path of the particle Linear (straight line)

BIOT SAVART LAW

$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I(d\vec{l} \times \hat{r})}{r^2}$

(i) Magnetic Field on the axis of a Circular Current Loop

$B = \frac{\mu_0}{4\pi} \frac{2\pi n I a^2}{(a^2 + x^2)^{3/2}}$

at the centre of the circular Coil $B_0 = \frac{\mu_0 n I}{2a}$

(ii) Magnetic Field due to a Straight wire carrying current of infinite length $B = \frac{\mu_0}{2\pi} \frac{I}{a}$

Ampere's Circuital Law

$\oint \vec{B} \cdot d\vec{l} = \mu_0 I$

Magnetic Field due to a Solenoid

$B = \mu_0 n I$ $\quad n = \frac{N}{L}$

Magnetic Field due to TOROID

$B = \mu_0 n I$ $\quad n = \frac{N}{2\pi r}$

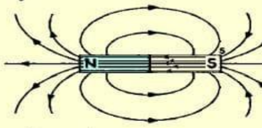
Force between two parallel Current Carrying Conductors

$F = \frac{\mu_0}{2\pi} \times \frac{I_1 I_2}{r}$

Magnetism and Matter

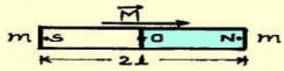
Properties of Magnetic Field Lines

- Outside the magnet the field lines are from north pole to south pole



- field lines form closed continuous loops
- field lines can not intersect each other
- magnitude of magnetic field is propotional to the density of magnetic field lines

Magnetic Dipole Moment



$\vec{M} = m(2\vec{l})$

- its direction is from south to north pole

Magnetic Field due to Bar Magnet

On axial line $\vec{B} = \frac{\mu_0}{4\pi}\frac{2\vec{M}}{d^3}$

On equatorial line $\vec{B} = -\frac{\mu_0}{4\pi}\frac{\vec{M}}{d^3}$

Torque on a Bar Magnet in a Magnetic field

$\tau = MB\sin\theta$

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

Curie Law in Magnetism

$\chi_m = \frac{C}{T}$

Gauss's Law

$\phi_B = \oint_S \vec{B}\cdot\vec{ds} = 0$

χ_m, μ_r and μ of magnetic substances

	substance	χ_m	μ_r	μ
1.	Diamagnetic	$-1 \le \chi_m < 0$	$0 \le \mu_r < 1$	$\mu < \mu_0$
2.	paramagnetic	$0 < \chi_m < 1$	$1 < \mu_r < (1+\delta)$	$\mu > \mu_0$
3.	Ferromagnetic	$\chi_m >> 1$	$\mu_r >> 1$	$\mu >> \mu_0$

* Here δ is a small positive number.

(i) Relative magnetic permeability

$\mu_r = \frac{\mu}{\mu_0}$ or $\mu_r = \frac{B}{B_0}$

$\mu_0 = 4\pi\times10^{-7}\ Wb\,A^{-1}m^{-1}$

(ii) Magnetising Force or Magnetic Intensity

$H = \frac{B_0}{\mu_0}$ or $H = \frac{B}{\mu}$

(iii) Magnetisation Intensity (I)

$I = \frac{\text{Magnetic moment}}{\text{Volume}} = \frac{M}{V}$

$I = \frac{m}{A}$ $\quad I = \frac{B_m}{\mu_0}$

(iv) Magnetic Susceptibility

$\chi_m = \frac{I}{H}$

$\mu_r = 1 + \chi_m$

Potential Energy of a Magnetic Dipole in a Magnetic Field

$U = -MB\cos\theta$

$U = -\vec{M}\cdot\vec{B}$

$\Delta U = W = -MB(\cos\theta_2 - \cos\theta_1)$

Hysteresis Loss Q = VAnt

n = frequency of cycles

t = time

V = Volume of the material

A : Area of hysteresis loop

ELECTROMAGNETIC INDUCTION

Faraday's Law of EMI

First Law - whenever the magnetic flux changes an e.m.f is induced in the circuit

Second Law -

Induced e.m.f. $e = -\frac{d\phi}{dt}$

Induced current $I = -\frac{N}{R}\frac{d\phi}{dt}$

Induced charge $\Delta Q = -\frac{N}{R}\Delta\phi$

Self Inductance

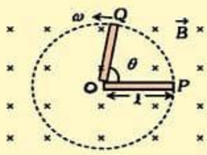
$L = \frac{\phi}{I}$

$e = -L\times\frac{dI}{dt}$

various formulae for L

Circular coil	Solenoid	Toroid
$L = \frac{\mu_0\pi N^2 r}{2}$	$L = \frac{\mu_0\mu_r N^2 A}{l}$	$L = \frac{\mu_0 N^2 r}{2}$

Rotating metallic rod

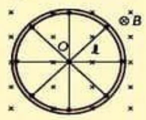


Induced e.m.f.

$e = \frac{1}{2}Bl^2\omega$

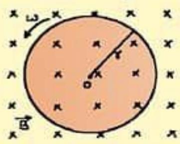
$e = \pi\nu Bl^2$

Cycle wheel



$e_{net} = e = \frac{1}{2}Bl^2\omega$

Rotation of a metal disc

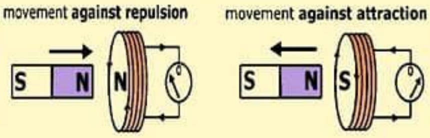


$e = \frac{1}{2}B\omega r^2$

Lenz's Law

movement against repulsion

movement against attraction



Mutual Inductance

$M = \frac{\phi_2}{I_1}$

$e_2 = -M\frac{dI_1}{dt}$

various formulae for M

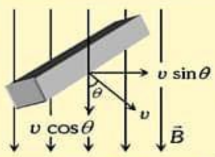
Two concentric coils	Two Solenoids
$M = \frac{\pi\mu_0 N_1 N_2 r^2}{2R}$	$M = \frac{\mu_0 N_1 N_2 A}{l}$

Coefficient of Coupling

$K = \frac{M}{\sqrt{L_1 L_2}}$

$0 \le K \le 1$

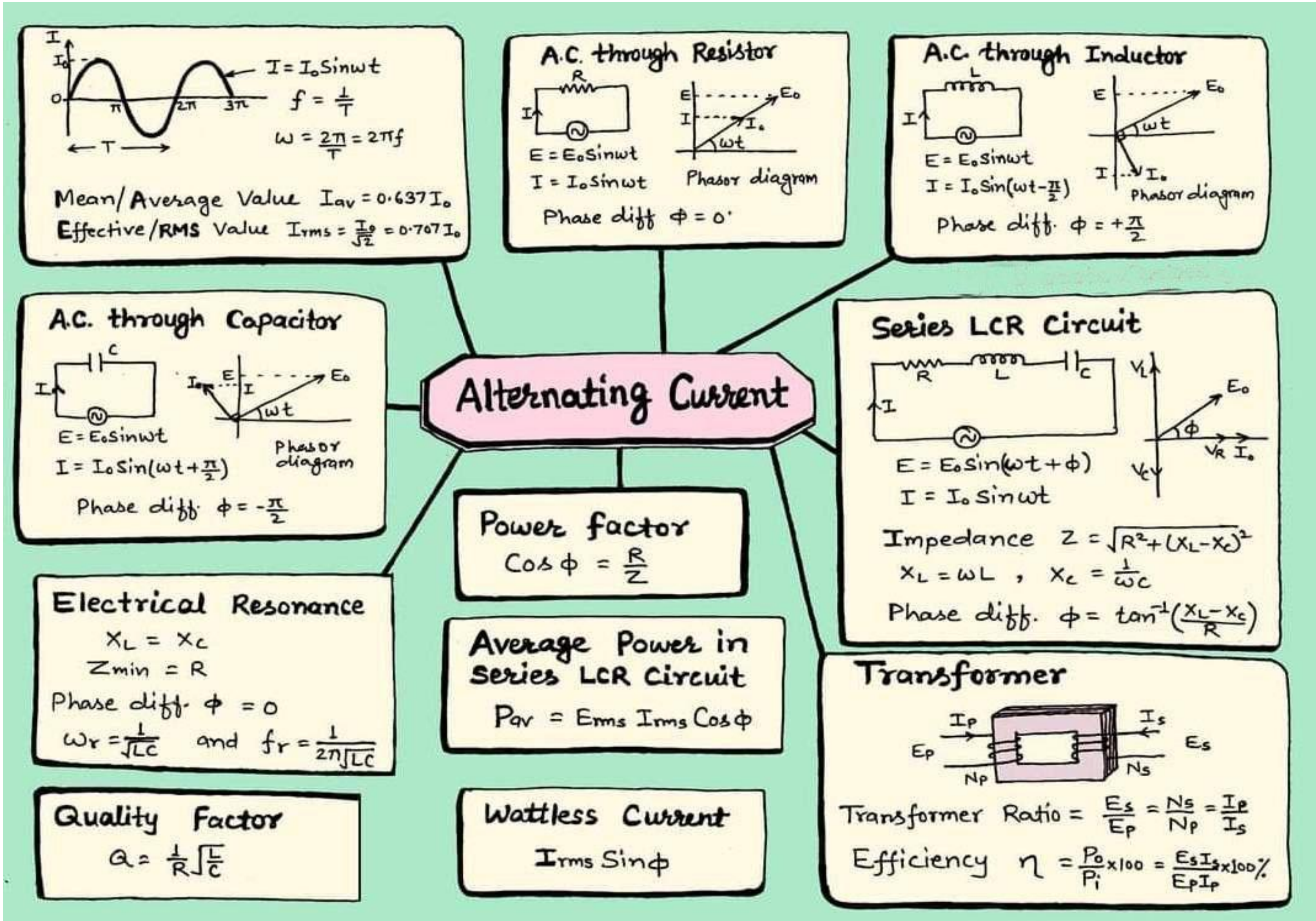
Motional Electromotive Force

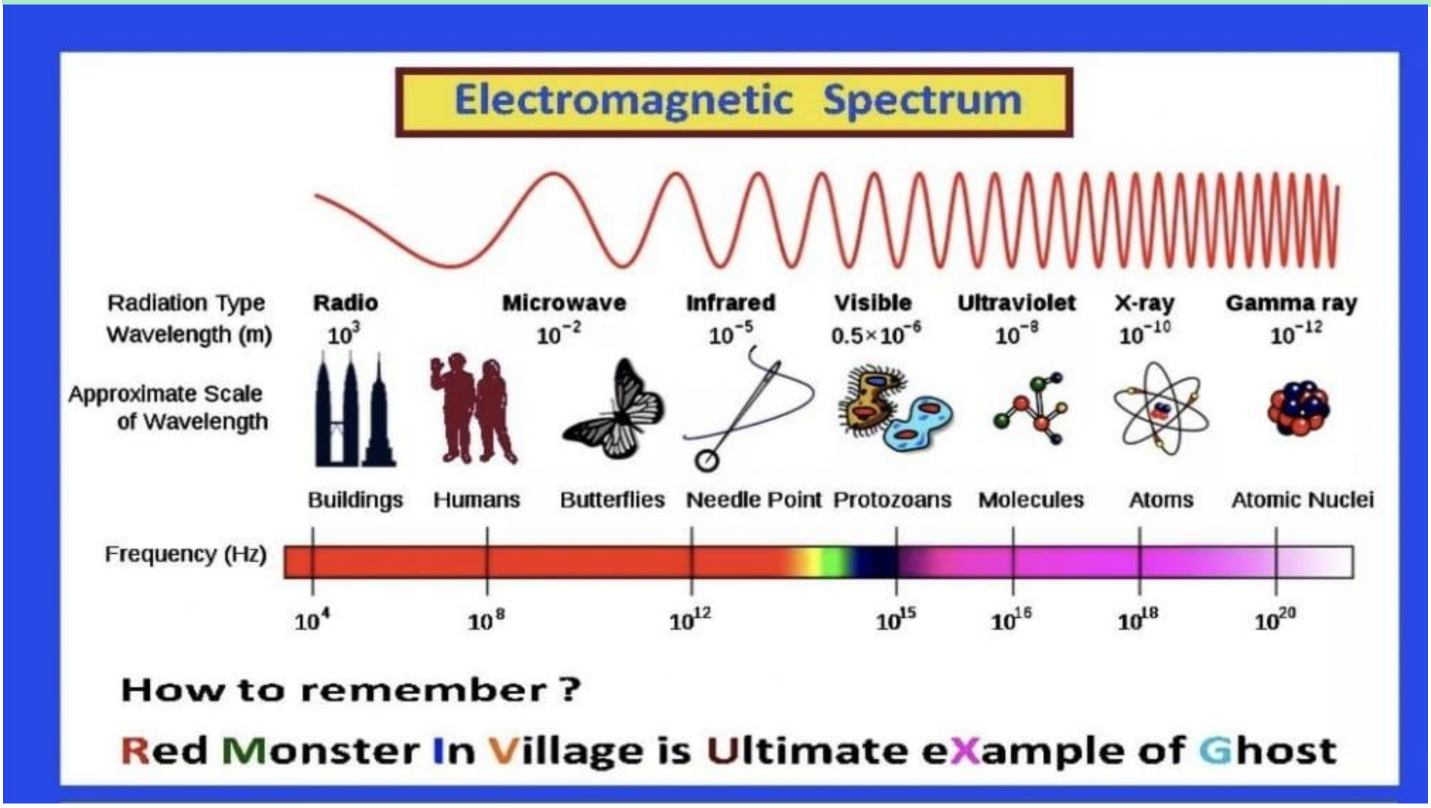


$e = Bl(v\sin\theta)$

Magnetic Energy of Inductor

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


Alternating Current
I = I₀ Sinωt
f = 1/T
ω = 2π/T = 2πf
Mean/Average Value Iav = 0·637 I₀
Effective/RMS Value Irms = I₀/√2 = 0·707 I₀
A.C. through Resistor
E = E₀ Sinωt
I = I₀ Sinωt
Phasor diagram
Phase diff. φ = 0°
A.C. through Inductor
E = E₀ Sinωt
I = I₀ Sin(ωt − π/2)
Phasor diagram
Phase diff. φ = +π/2
A.C. through Capacitor
E = E₀ Sinωt
I = I₀ Sin(ωt + π/2)
Phasor diagram
Phase diff. φ = −π/2
Series LCR Circuit
E = E₀ Sin(ωt + φ)
I = I₀ Sinωt
Impedance Z = √(R² + (XL − XC)²)
XL = ωL , XC = 1/ωC
Phase diff. φ = tan⁻¹((XL − XC)/R)
Power factor
Cos φ = R/Z
Electrical Resonance
XL = XC
Zmin = R
Phase diff. φ = 0
ωr = 1/√LC and fr = 1/(2π√LC)
Average Power in Series LCR Circuit
Pav = Erms Irms Cos φ
Transformer
Transformer Ratio = Es/Ep = Ns/Np = Ip/Is
Efficiency η = P₀/Pi ×100 = EsIs/EpIp ×100%
Quality Factor
Q = (1/R)√(L/C)
Wattless Current
Irms Sinφ


Electromagnetic Spectrum
Radiation Type
Wavelength (m)
Radio
10³
Microwave
10⁻²
Infrared
10⁻⁵
Visible
0.5×10⁻⁶
Ultraviolet
10⁻⁸
X-ray
10⁻¹⁰
Gamma ray
10⁻¹²
Approximate Scale of Wavelength
Buildings
Humans
Butterflies
Needle Point
Protozoans
Molecules
Atoms
Atomic Nuclei
Frequency (Hz)
10⁴
10⁸
10¹²
10¹⁵
10¹⁶
10¹⁸
10²⁰
How to remember ?
Red Monster In Village is Ultimate eXample of Ghost

RAY OPTICS

Mirror Formula $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

Linear Magnification $m = \frac{I}{O} = \frac{-v}{u}$

Concave Mirror

S.N.	Object	Image: Position	Image: Size	Image: Nature	Orientation
1.	at ∞	at Focus	Point	Real	Inverted
2.	between ∞ and C	between F and C	diminished	Real	Inverted
3.	at C	at C	Same	Real	Inverted
4.	between C and F	between C and ∞	Magnified	Real	Inverted
5.	at F	at ∞	Indefinetly Large	Real	Inverted
6.	between F and P	on other side of Mirror	Large	Virtual	Erect

Convex Mirror

S.N.	Object	Image: Position	Image: Size	Image: Nature	Orientation
1.	at ∞	at Focus	Point	Virtual	Erect
2.	between ∞ and C	between P and F	diminished	Virtual	Erect

Lens Maker's Formula

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

Lens Formula

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

Combination of Lenses in contact

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$

Power of a Lens $P = \frac{1}{f}$

Refractive Index $\mu = \frac{c}{v}$

Relative Refractive Index

$${}^1\mu_2 = \frac{\mu_2}{\mu_1} = \frac{c/v_2}{c/v_1} = \frac{v_1}{v_2}$$

Snell's Law

$$\mu_1 \sin i = \mu_2 \sin r$$

Essential Conditions for total Internal Reflection

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

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

$${}^a\mu_b = \frac{1}{\sin C}$$

a = rarer
b = dense
c = critical angle

Spherical Refracting Surfaces

(i) Refraction from Rarer to Denser Medium $\frac{\mu_1}{-u} + \frac{\mu_2}{v} = \frac{\mu_2 - \mu_1}{R}$

(ii) Refraction From Denser to Rarer Medium $\frac{\mu_2}{-u} + \frac{\mu_1}{v} = \frac{\mu_1 - \mu_2}{R}$

Astronomical Telescope

(i) Normal Adjustment

Magnifying Power $m = \frac{f_o}{-f_e}$

length of the telescope $L = f_o + f_e$

(ii) When the final Image is formed at the least distance of distinct vision (d)

Magnifying Power $m = -\frac{f_o}{f_e}\left(1 + \frac{f_e}{d}\right)$

length of the telescope $L = f_o + u_e$

Prism

Angle of deviation (δ)

$$\delta = (i_1 + i_2) - A$$

$$r_1 + r_2 = A$$

Prism formula

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

Compound Microscope

Magnifying power

$$m = \frac{-V_o}{u_o}\left(1 + \frac{d}{f_e}\right)$$

length of microscope tube

$$L = V_o + u_e$$

Resolving Power of Microscope

$$\text{R.P. of microscope} = \frac{1}{d} = \frac{2\mu \sin\theta}{1.22\lambda}$$

d = minimum distance between two objects

Resolving Power of telescope

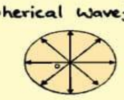
$$\text{R.P. of Telescope} = \frac{1}{d\theta} = \frac{D}{1.22\lambda}$$

D = diameter of the objective of the telescope
λ = wavelength of light used.

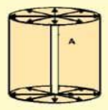
Wave Optics

Wavefront

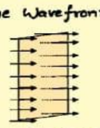
(i) Spherical Wavefront



(ii) Cylindrical Wavefront



(iii) Plane Wavefront



S.N.	Interference	Diffraction
1.	It is due to superposition of two distinct waves coming from two coherent sources.	It is produced as a result of superposition of the secondary wavelets coming from different parts of the same wavefront.
2.	In interference pattern all the bright fringes are of same intensity.	In diffraction pattern, all the bright bands are not of the same intensity.
3.	The width of the interference fringes may or may not be equal.	The fringe width of diffraction bands is unequal.

Diffraction of Light at a single slit

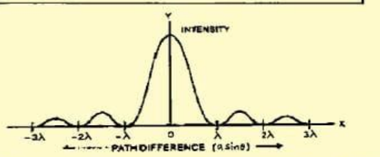
For n^{th} secondary minimum

$$a\sin\theta = n\lambda$$

for n^{th} secondary maximum

$$a\sin\theta = (2n+1)\frac{\lambda}{2}$$

$$\text{width of central Maximum} = \frac{2D\lambda}{a}$$



Resultant Amplitude and intensity in Interference

$y_1 = a_1 \sin\omega t$

$y_2 = a_2 \sin(\omega t + \phi)$

Resultant amplitude

$$A = \sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\phi}$$

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$$

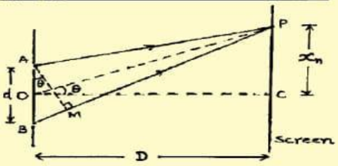
for bright fringe

$\phi = 2n\pi$ $\Delta = n\lambda$

for dark fringe

$\phi = (2n-1)\pi$ $\Delta = (2n-1)\frac{\lambda}{2}$

Fringe width in Interference



path difference $= \frac{dx}{D}$

For Constructive Interference

Position of Bright Fringe

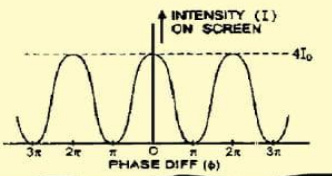
$$x_n = \frac{n\lambda D}{d}$$

Fringe width $\beta = \frac{D\lambda}{d}$

For destructive Interference

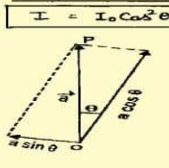
$$x_n = \frac{(2n-1)D\lambda}{2d}$$

Fringe width $\beta = \frac{D\lambda}{d}$



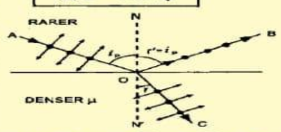
Law of Malus

$$I = I_0 \cos^2\theta$$



Brewster's Law

$$\mu = \tan i_p$$



Dual Nature of Radiation

- Light has both wave character as well as particle
- Interference explained by wave nature
- When light of sufficiently low wavelength, it behaves as a particle

Photons

Light particle having definite energy and definite linear momentum called "photon" or Energy packets.

Energy of each photon

$$= h\nu = hc/\lambda$$

Momentum of each photon

$$= h/\lambda = E/c$$

Contribution

Einstein, after an average academic career put forward quantum theory of light in 1905 while working as a grade III technical officer in a patent office

de-Broglie Relation

$\lambda = h/p$

$\lambda =$ wavelength associated with particle or de-Broglie wavelength

$p =$ momentum

$$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mKmax}}$$

Photoelectric Effect

- When light of sufficiently small wavelength is incident on metal surface, electrons are ejected from the metal, the phenomenon is called photoelectric effect.
- Ejected electrons are called photoelectrons

Dual Nature of Matter and Radiation

Davisson - Germer Expt.

A beam of electrons emitted by electron gun is made to fall on nickel crystal cut along cubical axis at a particular angle. Scattered beam of electrons is received by detector.

- Minimum energy equal to **work function** (ϕ) must be given to an electron so as to bring it out of the metal

Einstein's Photoelectric Eqn.

$K_{max} = E - \phi = eV_0$

$= \frac{hc}{\lambda} - \phi$

V_0 = Stopping Potential

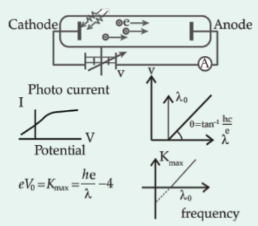
K_{max} = max. kinetic energy

$h\nu = h\nu_0 + K_{max}$

$K_{max} = h(\nu - \nu_0)$

If $\nu > \nu_0$, Photoelectric emission take place

If $\nu < \nu_0$, no electron will come out



Results: $\lambda =$ de Broglie's wavelength

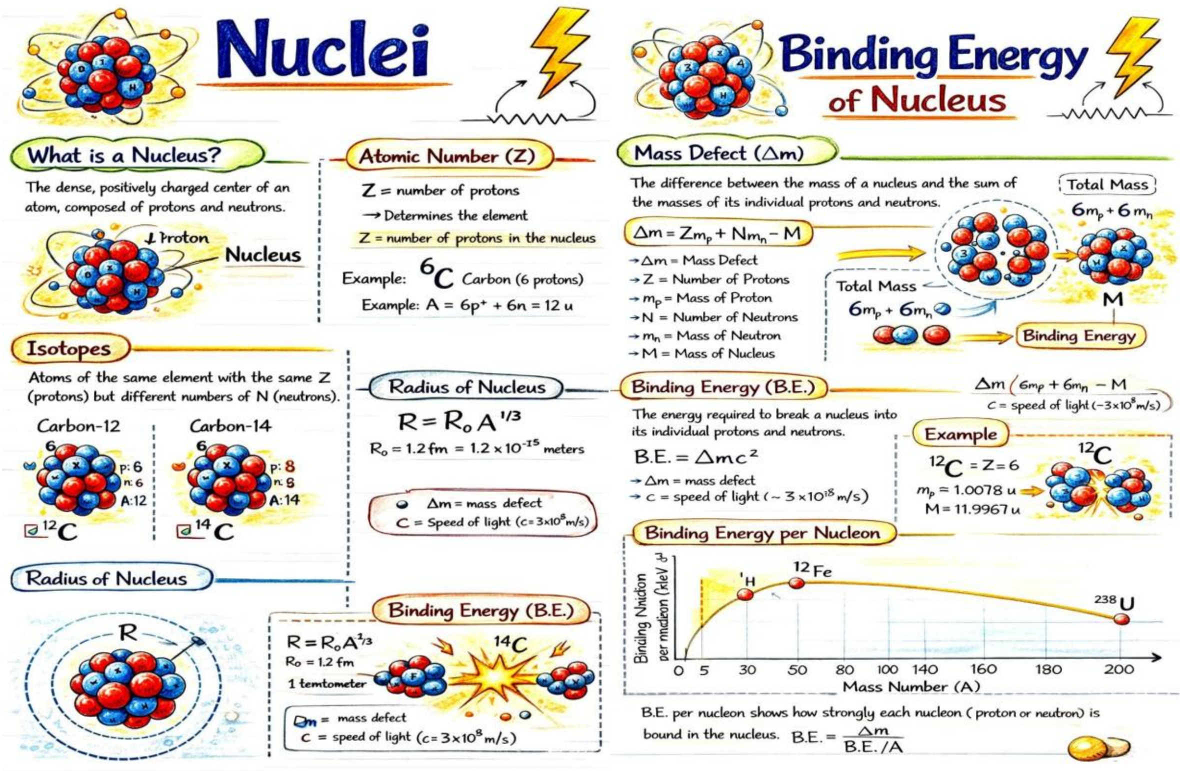
$= h/p$

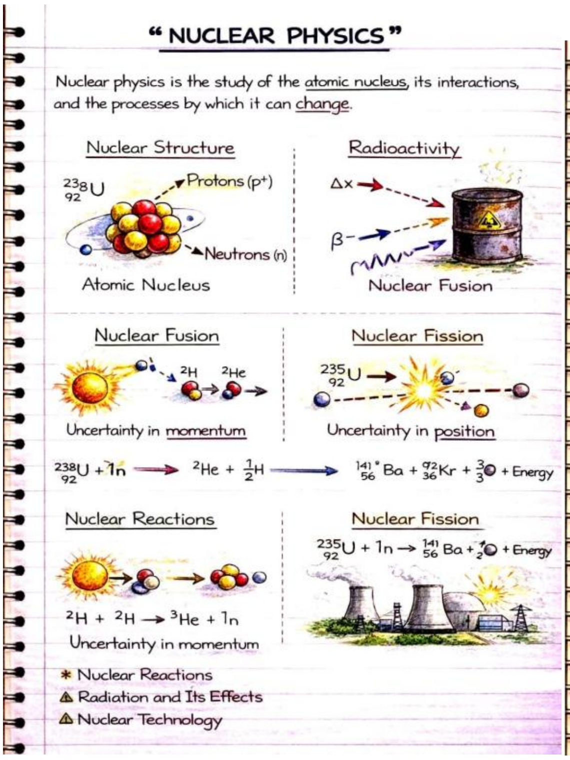
$= 1227/\sqrt{V}$nm

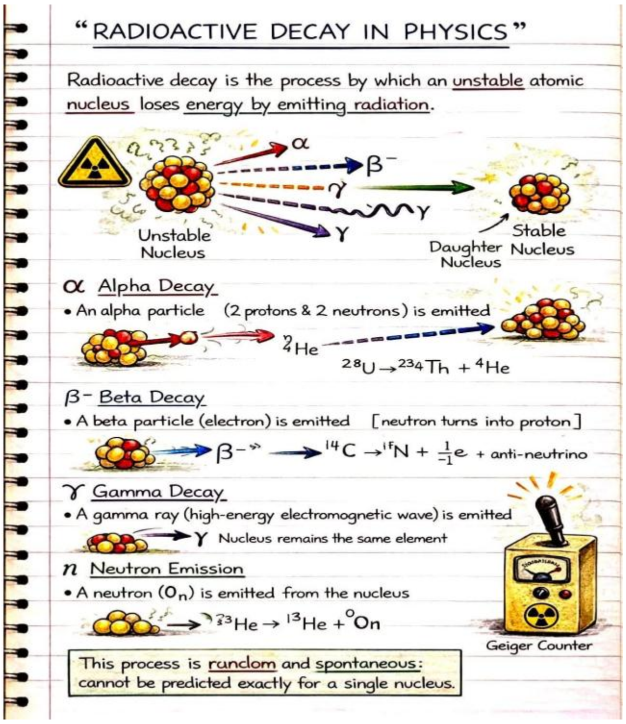
$= 1227/\sqrt{54}$ nm

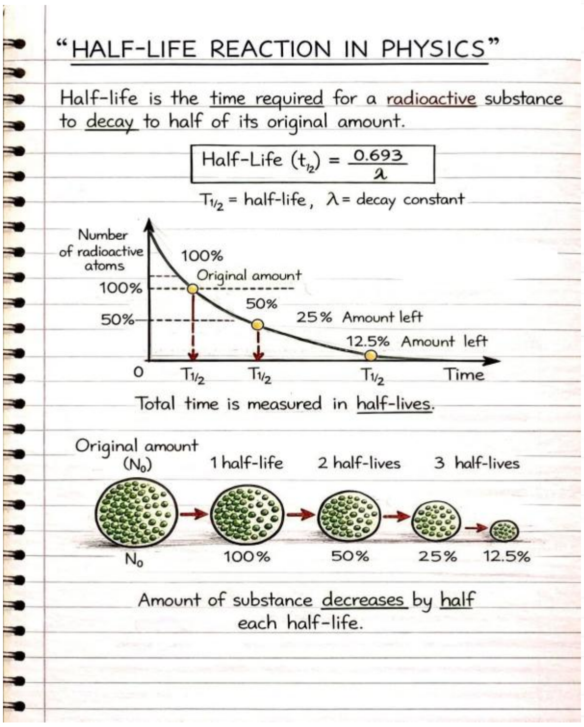
$= 0.167$ nm $= 1.67$ A°

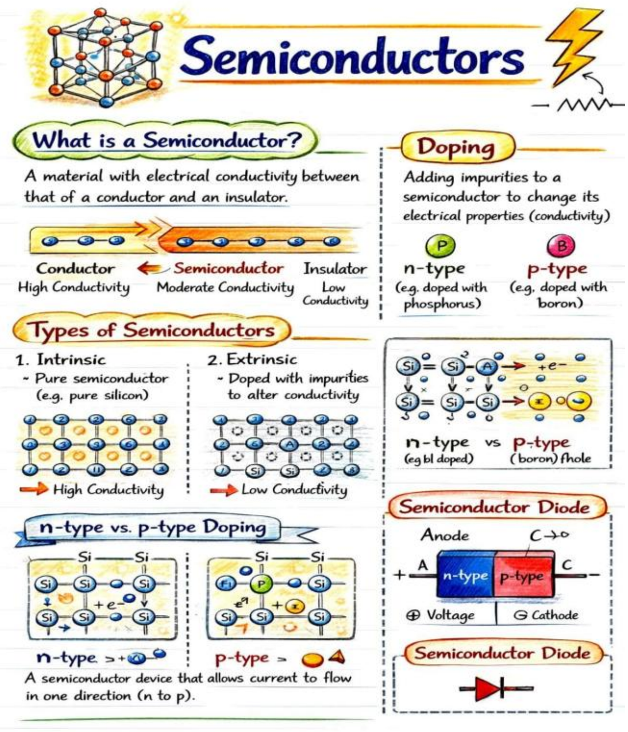
This experiment verifies the wave nature of electrons & relation with de-Broglie wavelength.




"NUCLEAR PHYSICS"
Nuclear physics is the study of the atomic nucleus, its interactions, and the processes by which it can change.
Nuclear Structure
Protons (p+)
Neutrons (n)
Atomic Nucleus
Radioactivity
Nuclear Fusion
Nuclear Fusion
Uncertainty in momentum
Nuclear Fission
Uncertainty in position
Nuclear Reactions
Nuclear Fission
2H + 2H → 3He + 1n
Uncertainty in momentum
Nuclear Reactions
Radiation and Its Effects
Nuclear Technology


"RADIOACTIVE DECAY IN PHYSICS"
Radioactive decay is the process by which an unstable atomic nucleus loses energy by emitting radiation.
Unstable Nucleus
Daughter Nucleus
Stable Nucleus
α Alpha Decay
• An alpha particle (2 protons & 2 neutrons) is emitted
β- Beta Decay
• A beta particle (electron) is emitted [neutron turns into proton]
γ Gamma Decay
• A gamma ray (high-energy electromagnetic wave) is emitted
Nucleus remains the same element
n Neutron Emission
• A neutron (0n) is emitted from the nucleus
Geiger Counter
This process is random and spontaneous: cannot be predicted exactly for a single nucleus.


"HALF-LIFE REACTION IN PHYSICS"
Half-life is the time required for a radioactive substance to decay to half of its original amount.
Half-Life (t½) = 0.693 / λ
T½ = half-life, λ = decay constant
Number of radioactive atoms
100%
Original amount
50%
25% Amount left
12.5% Amount left
Time
Total time is measured in half-lives.
Original amount (N0)
1 half-life
2 half-lives
3 half-lives
N0
100%
50%
25%
12.5%
Amount of substance decreases by half each half-life.


Semiconductors
What is a Semiconductor?
A material with electrical conductivity between that of a conductor and an insulator.
Conductor
High Conductivity
Semiconductor
Moderate Conductivity
Insulator
Low Conductivity
Doping
Adding impurities to a semiconductor to change its electrical properties (conductivity)
n-type
(e.g. doped with phosphorus)
p-type
(e.g. doped with boron)
Types of Semiconductors
1. Intrinsic
- Pure semiconductor (e.g. pure silicon)
High Conductivity
2. Extrinsic
- Doped with impurities to alter conductivity
Low Conductivity
n-type vs. p-type Doping
A semiconductor device that allows current to flow in one direction (n to p).
Semiconductor Diode
Anode
n-type
p-type
Voltage
Cathode
Semiconductor Diode

1. ELECTRIC CHARGES AND FIELDS

MULTIPLE CHOICE QUESTIONS:

1. **When a glass rod is rubbed with silk cloth,**
   (A) silk cloth will lose electrons to glass rod (C) glass rod acquires negative charge
   (B) glass rod will lose electrons to the silk cloth (D) silk acquires positive charge
2. **The electric field at a distance '*r*' from infinitely long straight uniformly charged wire is**
   (A) inversely proportional to *r* (C) inversely proportional to square of *r*
   (B) inversely proportional to cube of *r* (D) independent of *r*
3. **Which one of the following charges is NOT possible?**
   (A) 1.602×10^{-19} C (B) 3.204×10^{-19} C (C) 5.607×10^{-19} C (D) 6.408×10^{-19} C
4. **The electrostatic force between the two charges in vacuum is given by $F = k\frac{q_1 q_2}{r^2}$ where k is**
   (A) 9×10^9 Nm^2/ C^2 (B) 9×10^9 NC^2/ m^2 (C) 9×10^{-9} Nm^2/ c^2 (D) 9×10^9N
5. **The force on any charge due to a number of other charges is the vector sum of all the forces on that charge due to the other charges. This statement is called**
   (A) quantization principle of charges (C) principle of homogeneity
   (B) principle of superposition of electric forces (D) additivity of charges
6. **The direction of electric field vector at a point on the equatorial line of a dipole is**
   (A) in the same direction of dipole moment (C) towards negative charge
   (B) in the opposite direction to the dipole moment (D) towards positive charge
7. **Dipole moment is a vector quantity, which is pointing from**
   (A) $-q$ to $+q$ along the axis of an electric dipole. (C) infinity to $+q$
   (A) $+q$ to $-q$ along the axis of an electric dipole. (D) $+q$ to infinity.
8. **Name the physical quantity which has the dimensional formula [LTA]**
   (A) line charge density (B) capacitance (C) dipole moment (D) charge
9. **__________ placed in an electric field experiences a force in the direction opposite to the electric field.**
   (A) An electron (B) A positive charge (C) A neutron (D) A proton.
10. **When a free electric dipole placed in a non-uniform electric field, the dipole will experience**
    (A) both force and torque (C) only torque but not force
    (B) only force but not torque (D) neither torque nor force
11. **Electrostatic field lines can never form closed loops. This is due to**
    (A) Conservation of charges. (C) Quantization of electric charges
    (B) Conservation of momentum. (D) Conservative nature of electrostatic field
12. **SI unit of electric flux is**
    (A) NC^{-1} (B) Weber (C) NC^{-1}m^2 (D) Nm^{-2}C
13. **Electric field intensity at a distance *r* from center of uniformly charged sphere outside the sphere is *E*. Which one of the following is correct?**
    (A) $E \propto q$ and $E \propto \frac{1}{r}$ (B) $E \propto \frac{1}{q}$ and $E \propto \frac{1}{r}$ (C) $E \propto q$ and $E \propto \frac{1}{r^2}$ (D) $E \propto q$ and $E \propto \frac{1}{r^3}$
14. **The electric field due to an electric dipole at any point on its axis, which is at distance *r* (*r* >> length of dipole) from its center varies according to**
    (A) $E \propto r$ (B) $E \propto \frac{1}{r}$ (C) $E \propto \frac{1}{r^2}$ (D) $E \propto \frac{1}{r^3}$

15. **Some physical quantities are listed in column 1 and the SI UNITS are listed in column 2. Identify the correct match**

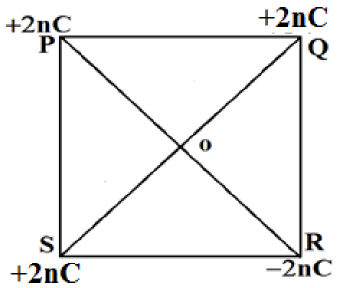
COLUMN 1	COLUMN 2
(i) Electric field	(a) $C^2N^{-1}m^{-2}$
(ii) Electric flux	(b) Vm^{-1}
(iii) Permittivity	(c) Vm

(A) (i)-(b), (ii)-(c), (iii)-(a) (C) (i)-(c), (ii)-(b), (iii)-(a)

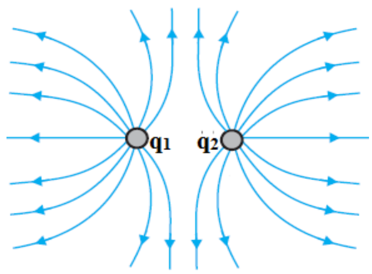
(B) (i)-(b), (ii)-(a), (iii)-(c) (D) (i)-(a), (ii)-(c), (iii)-(b)

16. **Statement (1): The electric field lines never cross each other.**
Statement (2): If electric field linescross each other, the field at the point of intersection will not have a unique direction, which is not possible.
(A) Both statements are correct Statement (2) is the correct explanation for Statement (1)
(B) Both statements are correct Statement (2) is not the correct explanation for Statement (1)
(C) Statement (1) is correct but Statement (2) is wrong.
(D) Statement (2) is correct but Statement (1) is wrong.

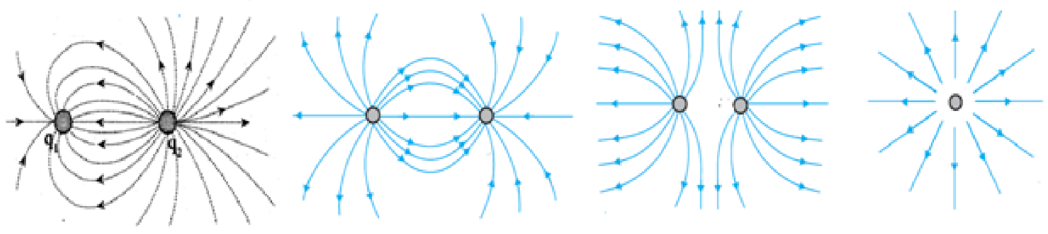
17. **Four charges are placed at the corners of a square PQRS as shown in the figure. The direction of the resultant electric field at the intersection of the diagonals is**
(A) Towards P
(B) Towards Q
(C) Towards R
(D) Towards S



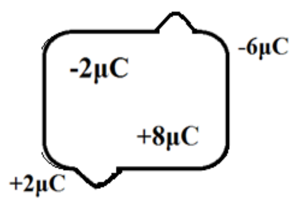
18. **The following figure shows the electric field around the two charges where,**
(A) q_1 is positive, q_2 is negative
(B) q_1 is negative, q_2 is positive
(C) both charges are positive
(D) both charges are negative



19. **Which one of the following shows the electric field lines due to an electric dipole?**



20. **The given figure is related to Gauss's law in electrostatics: $\phi = \frac{q}{\varepsilon_o}$, where q is equal to**
(A) + 2 μC (C) – 8 μC
(B) – 6 μC (D) + 6 μC



FILL IN THE BLANKS:

[*neutral, negative , positive, maximum, zero, infinity*]

1. The electric field lines due to a single positive charge end at __________.
2. The electric field inside a uniformly charged spherical shell is __________.

3. If area vector ΔS of a surface is parallel to the applied electric field E, then the electric flux ϕ through the surface is at its __________.
4. A neutron does not experience any force in an electric field because neutron is _______.
5. A body gains a ____________ charge when it loses electrons.

TWO MARK QUESTIONS:

1. Which types of charges are acquired by a plastic rod and wool when they are rubbed against each other?
2. Which are the two types of charges named by Benjamin Franklin?
3. Draw the neat, labeled diagram of gold leaf electroscope.
4. What are electric conductors? Give an example.
5. What are electric insulators? Give an example.
6. State and explain Coulomb's law.
7. Write Coulomb's law in vector form and explain the terms.
8. What is the SI unit for charge? Define the SI unit of charge.
9. The force between two point charges is F. What is the new force when the distance between them is halved?
10. Write the expression for electric field due to a point charge in vector form and explain the terms.
11. What are the factors on which electric field at a point due to a point source charge depends?
12. What are electric field lines? Do electrostatic field lines form closed loops?
13. Sketch the electric field lines due to (i) an electric dipole and (ii) a pair of positive charges.
14. Sketch the electric field lines for a (i) positive charge and (ii) negative charge.
15. Can two field lines intersect each other? Justify your answer.
16. Define electric flux through an area element. Mention the SI unit of electric flux.
17. Define electric dipole moment. Mention its SI unit
18. When does an electric dipole placed in a uniform electric field experience (a) maximum and (b) minimum torque?
19. Define linear charge density. Write its SI unit.
20. Define surface charge density. Write its SI unit.
21. Define volume charge density. Write its SI unit.
22. State and explain Gauss's law in electrostatics.
23. A glass rod is rubbed by silk cloth. Glass rod acquires a charge of 1.6×10^{-13} C. How many electrons are transferred to the silk cloth? **[10^6 electrons]**
24. A test charge of magnitude 1.5×10^{-9} C is placed at a point where electric field is 5.4×10^4 NC^{-1}. What is the force experienced by the test charge? **[8.1×10^{-5} N]**
25. A charge of 1 μC is distributed on a circular ring of radius 5 cm. Find the linear charge density. **[3.18×10^{-6} C/m]**
26. A charge of 1μC is distributed over a metallic spherical shell whose radius is 5 cm. Find the surface charge density. **[3.18×10^{-5} C/m^2]**
27. An electric dipole with dipole moment 4×10^{-9} Cm is aligned at 30° with the direction of a uniform electric field of magnitude 5×10^4 NC^{-1}. Calculate the magnitude of the torque acting on the dipole. **[1×10^{-4} Nm]**
28. A charge of 1 nC is placed in vacuum. Estimate the electric field at a distance of 2 cm from the charge. **[22500 NC^{-1}]**
29. Two point charges 2 nC and -4 nC are located at 0.02 m apart in vacuum. Find the force between them. **[1.8×10^{-4} N]**

THREE MARK QUESTIONS:

1. Describe an experiment to demonstrate that there are two types of charges using glass rod & plastic rod.
2. Write the three basic properties of electric charges.

3. State the principle of superposition of electric forces. Three equal positive charges are placed on the three corners A, B and C of a square ABCD. Sketch a diagram to show the resultant force on the charge at B.
4. Write three properties of electric field lines.
5. Derive the expression for the torque experienced by an electric dipole placed in a uniform electric field.
6. Two point charges 20 μC and 10 μC are separated by 0.05 m in free space. Find the force between them. Also calculate the force when a dielectric medium of dielectric constant 3 is introduced between them. **[720 N, 240 N]**
7. Two point charges q_A = 3 μC and q_B = – 3 μC are located 20 cm apart in vacuum. What is the electric field at the midpoint O of the line AB joining the two charges? **[5.4×10^6 NC^{-1} along OB]**
8. A point charge + 5 μC is placed at the center of the cube of side 4 cm. Find the electric flux through each square surface of the cube. **[9.4×10^4 Nm^2C^{-1}]**

FIVE MARK QUESTIONS:

1. Derive the expression for electric field at a point on the axial line of an electric dipole.
2. Derive the expression for electric field at a point on the equatorial plane of an electric dipole.
3. Using Gauss law, derive the expression for the electric field due to an infinitely long straight uniformly charged wire.
4. Derive the expression for electric field due to a uniformly charged infinite plane sheet using Gauss law.
5. Arrive at the expression for the electric field due to a thin spherical shell at a point outside the shell using Gauss law. Write the expression for electric field on its surface.
6. Charges of +10 nC, – 20 nC, – 10 nC and +20 nC are placed at the corners A, B, C and D respectively of a square ABCD of side 0.05 m calculate the resultant force on the charge at D. **[12.4×10^{-4} N]**
7. Four charges +Q, +2Q, +3Q and +4Q are placed at the corners of a square ABCD of side 0.1 m respectively. The electric field is at the center of the square is 5.1×10^3 NC^{-1}. Find Q. **[+ 1 nC]**
8. Two oppositely charged identical metallic spheres placed 0.5 m apart attract each other with a force of 0.108 N, when they are connected to each other by a copper wire for a short while, they begin to repel with a force of 0.036 N. Calculate the initial charges on the spheres. **[+3 μC, – 1 μC]**
9. Two positive charges of 0.2 μC and 0.8 μC are placed at a distance 0.15m apart. At what point on the line joining them the electric field zero? **[0.05 m from charge 0.2 μC, between two charges]**
10. A pendulum bob of mass 80 mg and carrying charge 2×10^{-8} C is at rest at a certain angle with the vertical in a horizontal uniform electric field of 20,000 Vm^{-1}. Find the tension in the thread of the pendulum and the angle it makes with the vertical. **[8.8×10^{-4} N, 27.02°]**

ANSWER KEYS TO MULTIPLE CHOICE QUESTIONS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
B	A	C	A	B	B	A	C	A	A	D	C	C	D	A	A	C	C	B	D

ANSWERS TO FIBS:

1. infinity 2. zero 3. maximum 4. neutral 5. Positive

****

2. ELECTROSTATIC POTENTIAL AND CAPACITANCE

MULTIPLE CHOICE QUESTIONS:

1. **Name the physical quantity whose SI unit is joule per coulomb.**
(A) Power (B) electric field (C) electric potential (D) dipole moment

2. **_______ is a unit of energy.**
(A) V (B) Vm (C) Vm^{-1} (D) eV

3. **Equal charges are given to the two spheres of different radii. The potential will:**
(A) Be more on bigger sphere (B) Be more on smaller sphere
(C) Be equal on both the spheres (D) Depend on the nature of the materials of the spheres

4. **For linear dielectrics, the ratio of dielectric polarisation to the applied electric field is equal to**
(A) Mobility (B) Dipole moment (C) $\epsilon_o \times$ Susceptibility (D) Permittivity

5. **The dimension of electric polarisation is given by**
(A) $[L^{-2}AT]$ (B) $[LAT]$ (C) $[ML^2A^{-1}T^{-3}]$ (D) $[M^{-1}L^{-2}A^2T^{-4}]$

6. **The electric potential at the surface of a charged spherical shell of radius 10 cm is 20 V. The electric potential at the center of the shell is**
(A) Zero (B) 10 V (C) 20 V (D) 30 V

7. **The electric field at a point which is very close to the surface of a charged conductor with surface charge density σ is**
(A) $E = \frac{\sigma}{2\varepsilon_0}$ (B) $E = \frac{\sigma}{\varepsilon_0}$ (C) $E = \frac{2\varepsilon_0}{\sigma}$ (D) $E = \frac{2\sigma}{\varepsilon_0}$

8. **The energy density between the plates of a charged capacitor is given by**
(A) $\frac{1}{2}CV^2$ (B) $\frac{1}{2}\varepsilon_o V^2$ (C) $\frac{1}{2}\varepsilon_o E^2$ (D) $\frac{1}{2}QV$

9. **The potential energy of an electric dipole placed in a uniform electric field is**
(A) $-\vec{p}.\vec{E}$ (B) $-\vec{p} \times \vec{E}$ (C) $\frac{1}{2}\mathrm{CV}^2$ (D) $\frac{1}{2}\epsilon_0\ \mathrm{E}^2$

10. **An electric dipole is placed in a uniform electric field. The dipole moment makes an angle *θ* with the electric field. For what angle *θ* is the potential energy of the dipole maximum?**
(A) $\theta = 0^o$ (B) $\theta = 45^o$ (C) $\theta = 90^o$ (D) $\theta = 180^o$

11. **Capacitance of a capacitor is defined as *C = q/V*. A factor on which capacitance of the capacitor depends is:**
(A) Charge *q* (C) Geometry of the conductor
(B) Potential deference *V* (D) all of the above

12. **Capacity of a parallel plate capacitor can be increased by**
(A) increasing the distance between the plates
(B) increasing the thickness of the plates
(C) decreasing the area of the plates
(D) decreasing the distance between the plates

13. **The potential energy of a capacitor is stored in the ___________ between the plates of the capacitor.**
(A) electric charges (B) electric field (C) magnetic field (D) current

14. **Which of the following correctly describes the behavior of polar and nonpolar dielectrics in an electric field?**
(A) Both polar and nonpolar dielectrics have permanent dipole moments, but only nonpolar dielectrics align in an external field.
(B) Polar dielectrics align their dipole moments with the external field, while in the case of nonpolar dielectrics a dipole moment is induced in response to the field.

(C) Nonpolar dielectrics align their permanent dipole moments in an external field, while polar dielectrics remain unaffected.

(D) Polaectrics and nonpolar dielectrics behave identically in the presence of an electric field, showing no difference in polarization.

15. An electric dipole is placed inside an insulating spherical shell. Pick the wrong statement.

(A) Net charge enclosed by the shell is zero

(B) Sphere acts as equipotential surface.

(C) Electric flux through the sphere is zero.

(D) Electric field is not uniform across the surface of the spherical shell.

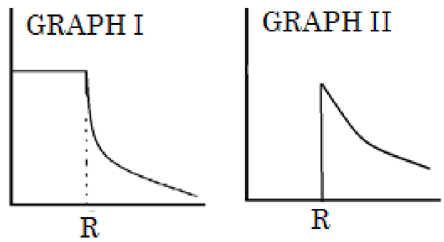
16. The following graphs show the variations of two physical quantities with distance '*r*' from the center of a uniformly charged spherical shell. Identify the graphs.

(A) First graph shows variation of E versus r and second is V versus r

(B) First graph shows variation of V versus r and second is E versus r

(C) Both graphs shows the variation of V versus r

(D) Both graphs shows the variation of E versus r



17. Statement 1: The electric field inside a conductor is zero.

Statement 2: All the charges reside only on the surface of the conductor.

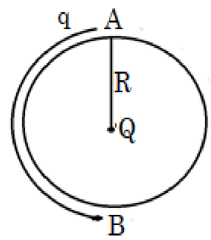
(A) Both statements are correct and Statement 2 is the correct explanation for the Statement 1.

(B) Both statements are correct and Statement 2 is not correct explanation for the Statement 1.

(C) Statements 1 is correct and Statement 2 is wrong

(D) Statements 1 is wrong and Statement 2 is correct

18. An imaginary sphere radius *R* is drawn around a charge *Q*, keeping the charge *Q* at its center. The work required to move a test charge *q* from point A to point B is



(A) $q(2R)$ (C) zero

(B) qV_A (D) qV_B

19. Consider the following statements:

Statement 1: The equipotential surface at a point is always normal to the electric field at that point.

Statement 2: If the electric field were not normal to the equipotential surface, work has to be done in moving a test charge on the surface.

(A) Both statements are correct and Statement 2 is the correct explanation for the Statement 1.

(B) Both statements are correct and Statement 2 is not the correct explanation for the Statement 1.

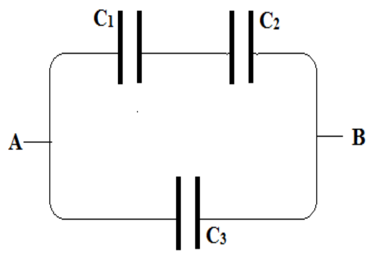
(C) Statements 1 is correct and Statement 2 is wrong

(D) Statements 1 is wrong and Statement 2 is correct

20. The equivalent capacitance of the combination is

(A) $\frac{C_1C_2}{C_1+C_2}+\frac{1}{C_3}$ (C) $\frac{C_1C_2C_3}{C_1+C_2+C_3}$

(B) $\frac{C_1C_2+C_2C_3+C_3C_1}{C_1+C_2+C_3}$ (D) $\frac{C_1C_2+C_2C_3+C_3C_1}{C_1+C_2}$



FILL IN THE BLANKS:

[*zero, constant, dielectric constant, electric dipole, point charge, maximum*]

1. The electric potential at the surface of a charged spherical shell is…………

2. The potential energy of an electric dipole, when dipole moment $\vec{p}$ is perpendicular to electric field $\vec{E}$ is………………

3. The ratio of permittivity of a medium to the permittivity of free space is called ……….
4. The electric potential at a point due to a/an ………… varies inversely as its distance from the given point.
5. The electric potential at any point on the equatorial plane of a/an ……………. is zero.

TWO MARK QUESTIONS:

1. Define electrostatic potential. Mention its SI unit.
2. What is electrostatic shielding? Mention one use of it.
3. Write the expression for the potential at any point due to an electric dipole and explain the terms.
4. Why the electrostatic field is zero inside a conductor?
5. What work is done in moving any charge from the center of a charged spherical shell to any point inside it? Justify your answer.
6. In the expression for the relation between electric field and potential which are the two important conclusions we arrive at?
7. What are the two main factors on which the extent of polarization of a dielectric medium depends?
8. What are dielectrics? Define electric polarization.
9. What is dielectric strength? Mention its SI unit
10. Define electric polarization for linear isotropic dielectrics. Mention its SI unit
11. Define equipotential surface. Draw equipotential surfaces for an electric dipole.
12. Draw equipotential surfaces for (a) a uniform electric field and (b) two identical positive charges.
13. Define capacitance of a conductor. Write the circuit symbol for a capacitor.
14. Write the SI unit of capacitance. Define the SI unit of capacitance.
15. Write the expression for energy density in case of a charged capacitor and explain the symbols used.
16. Write the expression for energy stored in a capacitor and explain the terms.
17. Find the potential at a point due to a charge of 4×10^{-9} C located 9 cm away from it. **[400 V]**
18. An electric dipole is placed in a uniform electric field with dipole moment vector perpendicular to the external electric field. Find the work required to turn the dipole so as to align dipole moment vector anti parallel to electric field. Given: Dipole moment = 6 μCm, External electric field = 10^6 Vm^{-1} **[6 J]**
19. The electrostatic potential at a point is 10 V. Then find the work required to move a charge of 20 μC from infinity to that point. **[200 μC]**
20. Capacitance of a parallel plate capacitor with air between the plates is 18 pF. When air is replaced by a dielectric slab, the capacitance becomes 54 pF. Find the dielectric constant of the slab. **[3]**
21. A 600 pF capacitor is charged by a 200 V supply. It is then disconnected from the supply and is connected to another uncharged 600 pF capacitor. Find the common potential difference. **[100 V]**

THREE MARK QUESTIONS:

1. Derive the expression for electric potential due to a system of charges.
2. Obtain the expression for the relation between electric field and electric potential.
3. Arrive at the expression for the potential energy of a system of two charges in the absence of external electric field.
4. Obtain the expression for the potential energy of a system of two charges in the presence of an external electric field.
5. Derive an expression for potential energy stored in an electric dipole placed in a uniform electric field.
6. Distinguish between polar and non-polar dielectrics. Give an example for each.
7. Mention the properties of equipotential surface.
8. Write any three electrostatic properties of conductors in electrostatic field.
9. Mention any three factors on which the capacitance of a parallel plate capacitor depends.

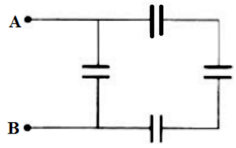
10. Capacitance of a parallel plate capacitor is 1 nF and the plates are separated by 2 mm. Find the area of each plate of the capacitor. **[0.226 m^2]**

11. Two charges of 10 μC and 5 μC are 12 cm apart. Find the work done in bringing charges 2 cm closer. **[7.5×10^5 J]**

12. Two capacitors of capacitances 2 pF and 4 pF are connected in parallel across 100V supply. What is the total capacitance of the combination? Determine the charge on each capacitor. **[6 pF, 200pC, 400 pC]**

13. Two capacitors of capacitances 2 pF and 4 pF are connected in series with 100 V supply. What is the total capacitance of the combination? Determine the potential difference across each capacitor. **[1.33 pF, 66.5 V, 33.5 V]**

14. In the following diagram, value of each capacitor is equal to 3 μF. Find the equivalent capacitance across AB. **[4 μF]**



FIVE MARK QUESTIONS:

1. Derive an expression for the electric potential due to an electric dipole.
2. Derive the expression for electric potential at a point due to a point charge.
3. Define capacitance of a capacitor. Arrive at the expression for the capacitance of a parallel plate capacitor.
4. Derive the expression for the effective capacitance of a series combination of two different capacitors.
5. Obtain the expression for the effective capacitance of a parallel combination of two different capacitors.
6. Two charges 5×10^{-8} C and -3×10^{-8} C are located 16 cm apart. Find the positions along line joining the two charges at which the electric potential zero? **[6 cm & 24 cm from – ve charge]**
7. Charges +2 nC, +4 nC, and +8 nC are placed at the corners ABC respectively of a square of side 0.2 m. Calculate the work done to transfer a charge of +2 nC from the corner D to the center of the square. **[627.4×10^{-9} J]**
8. An 800 pF capacitor is charged by a 100 V battery. How much energy is stored by the capacitor? The capacitor is disconnected from the battery and connected to another 800 pF capacitor. What is the electrostatic energy of the system? **[2×10^{-6} J]**
9. Two capacitors of capacitances 2 μF and 8 μF are connected in series and the resulting combination is connected across a 300 V battery. Calculate the charge, potential difference and the energy stored in each capacitor. **[Charge = 4.8×10^{-4} C, potential = 240 V, 60 V, energy = 5.76×10^{-2} J & 1.44×10^{-2} J]**
10. In a parallel plate capacitor with air between the plates, each plate has an area of 6×10^{-3} m^2 and the distance between the plates is 3 mm. Calculate the capacitance of the capacitor. If charge on each plate is 1.8×10^{-9} C, find the energy stored in the capacitor. **[18 pF, 9×10^{-8} J]**

ANSWER KEYS TO MULTIPLE CHOICE QUESTIONS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
C	D	B	C	A	C	B	C	A	D	C	D	B	B	B	B	A	C	A	D

ANSWERS TO FIBS:

1. constant 2. Zero 3. dielectric constant 4. point charge 5. electric dipole

****

3. CURRENT ELECTRICITY

MULTIPLE CHOICE QUESTIONS:

1. **The SI unit of current is**
   (A) coulomb (B) ampere (C) newton (D) farad
2. **When no current is passed through a conductor,**
   (A) the free electrons do not move
   (B) the average speed of a free electron over a large period of time is not zero
   (C) the average velocity of a free electron over a large period of time is zero
   (D) the average of the velocities of all the free electrons at an instant is non zero
3. **In the absence of an electric field, the mean velocity of free electrons in a conductor at absolute temperature (T) is**
   (A) Zero (B) independent of T (C) proportional to T (D) proportional to T^2
4. **Ohm's law is valid when the temperature of conductor is**
   (A) very low (B) very high (C) constant (D) varying
5. **In the equation AB = C, A is the current density, C is the electric field, Then B is**
   (A) resistivity (B) conductivity (C) resistance (D) potential difference
6. **Which of the following is non-ohmic resistance?**
   (A) Lamp filament (B) Copper wire (C) Carbon resistor (D) Diode
7. **The relaxation time in conductors**
   (A) increases with the increase of temperature (B) decreases with the increase of temperature
   (C) it does not depend on temperature (D) all of sudden changes at 400 K
8. **With increase in temperature the conductivity of**
   (A) semiconductors increases and metals decreases.
   (B) metals increases and of semiconductor decreases.
   (C) in both metals and semiconductors increases.
   (D) in both metal and semiconductor decreases.
9. **Drift velocity of electrons is due to**
   (A) motion of conduction electrons due to random collisions.
   (B) motion of conduction electrons due to electric field E
   (C) repulsion to the conduction electrons due to inner electrons of ions.
   (D) collision of conduction electrons with each other.
10. **Constantan wire is used for making standard resistance, because it has**
    (A) high melting point (B) low specific resistance
    (C) high specific resistance
    (D) negligible temperature coefficient of resistance
11. **The resistivity of a wire**
    (A) increases with the length of the wire
    (B) decreases with the area of cross-section
    (C) decreases with the length and increases with the cross-section of wire
    (D) none of the above statement is correct
12. ***n* identical cells of each emf *E* and internal resistance *r* are connected in series. An external resistance *R* is connected in series with this combination. The current through *R* is**
    (A) $\frac{nE}{R+nr}$ (B) $\frac{nE}{nR+r}$ (C) $\frac{E}{R+nr}$ (D) $\frac{nE}{R+r}$
13. **If the terminals of a cell are connected to an external resistance then the potential difference across its terminals is**
    (A) more than emf of the cell (B) less than emf of the cell
    (C) equal to emf of the cell (D) equal to potential drop across its internal resistance

14. **Kirchhoff's first law, i.e., $\sum I = 0$ at a junction, deals with the conservation of**
(A) Energy (B) Momentum (C) Charge (D) angular momentum

15. **If in the experiment of Wheatstone bridge, the positions of cell and galvanometer are interchanged, then balance point will**
(A) Change
(B) Remain unchanged
(C) Depend on the internal resistance of cell and resistance of galvanometer
(D) None of these

16. Column-I gives certain physical terms associated with flow of current through a metallic conductor. Column-II gives some mathematical relations involving electrical quantities. Match Column-I and Column-II with appropriate relations.

Column I	Column II
17. Relaxation Time	(a) $\mathbf{nev_d}$
18. Drift Velocity	**(b)** $\frac{E}{J}$
19. Current Density	**(c)** $\frac{m}{ne^2\rho}$
20. Electrical Resistivity	**(d)** $\frac{eE}{m}\tau$

(A) (i)-(d), (ii)-(c), (iii)-(b), (iv)-(a) (B) (i)-(c), (ii)-(d), (iii)-(a), (iv)-(b)
(C) (i)-(a), (ii)-(d), (iii)-(b), (iv)-(c) (D) (i)-(b), (ii)-(a), (iii)-(c), (iv)-(d)

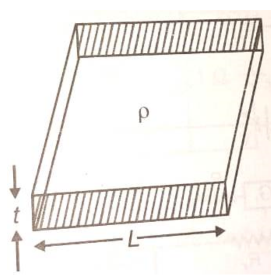
17. **The resistance of a wire is *R* Ω. If it is melted and stretched to *n* times its original length, its new resistance will be**
(A) $\frac{R}{n^2}$ (B) nR (C) $\frac{R}{n}$ (D) n^2R

18. **Statement I: When a wire is not connected to battery, then no current flows.**
Statement II: In the absence of electric field free electrons moves randomly or does not move in particular direction.
(A) Both Statements I and Statement II are true and the Statement II is a correct explanation of the Statement I.
(B) Both Statements I and Statement II are true but Statement II is not a correct explanation of the Statement I.
(C) Statement I is true but the Statement II is false.
(D) Statement I and Statement II both are false.

19. **Which of the following is different from the others?**
(A) volt^{2}ohm^{-1} (B) ampere^{2}ohm (C) volt-ampere (D) joule second^{-2}

20. **When a steady current flows through a metal conductor of non-uniform cross-section, then drift velocity is**
(A) Independent of area of cross-section
(B) Directly proportional to the area of cross-section
(C) Inversely proportional to the area of cross- section
(D) Inversely proportional to the square of area of cross-section

21. **Consider a thin square sheet of side L and thickness t, made of a material of resistivity ρ. The resistance between two opposite faces, shown by the shaded areas in the figure is**



(A) Directly proportional to t (B) Directly proportional to L
(C) Independent of t (D) Independent of L

FILL IN THE BLANKS:

(***mobility, energy, charge, electric resistivity, zero, superconductivity***)

1. In a current carrying conductor the net charge is __________.
2. The magnitude of the drift velocity per unit electric field is _________.
3. The SI unit of __________ is Ωm.
4. The resistivity of certain metals or alloys drops to zero when they are cooled below a certain temperature, this phenomenon is known as __________.
5. The Kirchhoff's loop rule is based on law of conservation of _________.

TWO MARK QUESTIONS:

1. A large number of free electrons are present in metals. Why there is no current in the absence of electric field?
2. State and explain Ohm's law.
3. How does the resistance of a conductor vary with its (i) length and (ii) area of cross section?
4. Mention the expression for resistance in terms of resistivity and explain the terms.
5. Define electrical resistivity of a conductor. Mention its SI unit.
6. Mention any two factors on which resistivity of a metal depend.
7. Write any two differences between resistance and resistivity.
8. Define electrical conductivity of a conductor. Mention its SI unit.
9. Define current density in a conductor. Mention its SI unit.
10. Write another equivalent form of Ohm's law in terms of current density and conductivity and explain the terms.
11. Write any two limitations of Ohm's law.
12. What are ohmic and non-ohmic devices? Give an example for each.
13. Draw V-I graph for an ohmic and a non- ohmic material.
14. Define the terms (i) drift velocity and (ii) relaxation time.
15. Define mobility of free electron. Give its SI unit.
16. Obtain the expression for mobility of free electron in terms of relaxation time.
17. Write the expression for resistivity in terms of number density and relaxation time and explain the terms.
18. What is the cause of resistance of a conductor? Explain
19. Write an expression for the resistivity of a metallic conductor, showing its variation over a limited range of temperature and explain the terms.
20. How does the resistivity of a metallic conductor (copper) vary with temperature? Show its variation graphically.
21. How does the resistivity of alloys (nichrome) vary with temperature? Show its variation graphically.
22. How does the resistivity of a semiconductor vary with temperature? Show its variation graphically.
23. Define the terms (i) electrical energy and (ii) electrical power.
24. Mention the expression for power loss (ohmic loss) in a conductor and explain the terms.
25. Why high voltage power from power generating station is preferred than high current for transmission of electrical power.
26. Define emf and internal resistance of a cell.
27. Terminal potential difference is less than the emf of a cell. Why?
28. For what basic purpose, the cells are connected (1) in series (2) in parallel?
29. State and explain Kirchhoff's junction rule/ current law.
30. State and explain Kirchhoff's loop rule / voltage law.
31. How many number of electrons that should flow per second in a conductor to provide a current of 1 A? **[6.25×10^{18} electrons per second]**
32. A potential difference of 20 volts is applied across the ends of a resistance of 5 Ω. What current will flow in the resistor? **[4 A]**

33. An electric bulb draws a current of 0.35 A for 20 minutes. Calculate the amount of electric charge that flows through the circuit. **[420 C]**

34. A cell of emf 2V and internal resistance 1 Ω is connected across a resistor of 9 Ω. Find the terminal potential difference of the cell. **[1.8 V]**

35. Calculate the resistance of a 40 W automobile headlight designed for 12 V. **[3.6 Ω]**

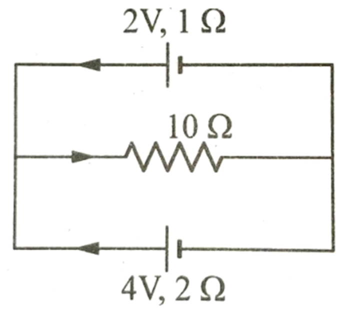
THREE MARK QUESTIONS:

1. Write any three factors on which resistance of a conductor depend.
2. Arrive at $\vec{J} = \sigma\vec{E}$, where symbols have their usual meaning or derive the expression for current density in terms of electric field and conductivity of the material using ohm's law.
3. What is meant by drift of free electrons in a conductor? Explain.
4. Derive an expression for drift velocity of free electrons in conductor.
5. Name the mobile charge carriers in (i) metals, (ii) an ionized gas and (iii) electrolyte.
6. Write any three differences between emf and terminal p. d. of a cell.
7. Obtain an expression for current drawn by an external resistance using Ohm's law. Or. Arrive at the relation between terminal potential difference and emf of a cell using ohm's law.
8. Charge through a cross section of conductor is given by $Q = (2t^2 - 5t)$ C. Find the current through the conductor at the instant $t = 2$ s. **[3 A]**
9. Find the average drift speed of free electrons in a copper wire of cross sectional area 10^{-7} m^2 carrying current of 1.5 A and having free electron density 8.5×10^{28} m^{-3}. **[1.1×10^{-3} ms^{-1}]**
10. Current 2 A is flowing through a conductor of resistance 4 Ω. Find the electrical energy consumed by the conductor in 10 s. **[160 J]**

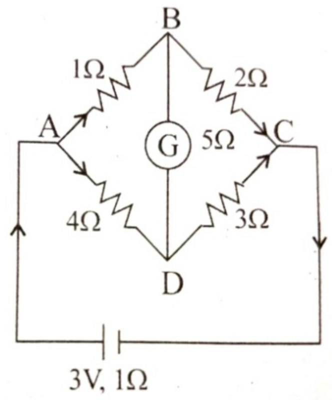
FIVE MARK QUESTIONS:

1. Derive an expression for electric current in terms of drift velocity and number density of free electrons.
2. Assuming the expression for electric current, arrive at the expression for electrical conductivity of a material.
3. Deduce the expressions for the equivalent emf and internal resistance of two cells connected in series.
4. Derive the expressions for the equivalent emf and internal resistance of two cells connected in parallel.
5. Obtain the condition for balance of Wheatstone network using Kirchhoff's laws.
6. A copper wire has 3×10^{22} free electrons in 0.021 m length. The drift velocity of electrons is found to be 2×10^{-5} ms^{-1}. How many electrons would pass through a given cross-section of the wire in one second? **[2.858×10^{19} ele/s]**
7. A copper wire has a diameter of 0.5 mm and resistivity of 1.68×10^{-8} Ωm. What will be the length of this wire to make its resistance of 2 Ω? How much does the resistance change if the diameter is doubled? **[23.8 m, 0.5 Ω]**
8. A battery of 6V gives a current of 2 A when connected to a resistance of 2 Ω. What is the internal resistance, terminal p.d. and lost voltage of the battery? **[1 Ω, 4 V, 2 V]**
9. Two cells of emf 3 V and 4 V and internal resistance 1 Ω and 2 Ω respectively are connected in parallel so as to send the current in the same direction through an external resistance of 10 Ω. Find the potential difference across 10 Ω resistor. **[3.125 V]**
10. In a Wheatstone bridge, resistances R_1, R_2, R_3 and R_4 are 10 Ω, 20 Ω, 30 Ω and 50 Ω respectively. Is the network balanced? If not, how do you vary (i) the arm R_3 and (ii) the arm R_4 to balance the network? **[No, 150 Ω, 10 Ω]**

11. Calculate the power dissipated in 10 Ω resistor in the given circuit. **[0.625 W]**



12. In the given circuit, calculate the current through the galvanometer (I_g) **[I_g = 0.0652 A]**



ANSWER KEYS TO MULTIPLE CHOICE QUESTIONS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
B	C	A	C	A	D	B	A	B	D	D	A	B	C	B	B	D	A	D	C	D

ANSWERS TO FIBS:

1. zero 2. mobility 3. electrical resistivity 4. superconductivity 5. Energy

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4: MOVING CHARGES AND MAGNETISM

MULTIPLE CHOICE QUESTIONS:

1. **Who concluded that moving charges or currents produces a magnetic field?**
(A) J. C. Maxwell (B) H. C. Oersted (C) J. A. Fleming (D) J. C. Bose
2. **When a magnetic compass needle is carried nearby to a straight wire carrying current, then**
(I) the straight wire cause a noticeable deflection in the compass needle.
(II) the alignment of the needle is tangential to an imaginary circle with straight wire as its centre and has a plane perpendicular to the wire
(A) (I) is correct (B) (II) is correct
(C) both (I) and (II) are correct (D) neither (I) nor (II) is correct
3. **If a current I is flowing in a straight wire parallel to x axis and magnetic field is there along the y axis then**
(A) The wire experiences force in x direction (B) The wire experiences force in y direction
(C) The wire experiences no force (D) The wire experiences force in z direction

4. A strong magnetic field is applied on a stationary electron. Then the electron

(A) moves in the direction of the field. (B) remains stationary.

(C) moves perpendicular to the direction of the field (D) moves opposite to the direction of the field.

5. The radius of the circle described by a charged particle moving perpendicular to a uniform magnetic field depends on

(A) its mass only (B) its velocity only

(C) both mass and velocity (D) neither mass nor velocity

6. The frequency of rotation of the charge particle in a uniform magnetic field is independent of

(A) velocity of the particle (B) charge of the particle

(C) mass of the particle (D) strength of the magnetic field

7. Which of the following statements is not true regarding Biot-Savart's law,

(A) the magnetic field is proportional to the length of the current element,

(B) the magnetic field is proportional to the current through the current element

(C) the magnetic field is inversely proportional to the distance of the point

(D) the magnetic field is proportional to the sine of the angle between the current direction and the line joining the current element and the point

8. The value of permeability of free space is

(A) $4\pi \times 10^{-7}$ H/m (B) 9×10^{9} Nm^2/C^2 (C) 8.854×10^{-12} F/m (D) 3×10^{8} m/s

9. A long straight wire carrying a current induced magnetic induction at any place that is

(A) proportional to the distance from the wire

(B) independent of distance.

(C) inversely proportional to the distance from the wire

(D) inversely proportional to the square of the distance from the wire

10. An electron is projected with uniform velocity along the axis of a current carrying long solenoid. Which of the following is true?

(A) The electron will be accelerated along the axis.

(B) The electron path will be circular about the axis.

(C) The electron will experience a force at 45° to the axis and hence execute a helical path.

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

11. If the beams of electrons and protons move parallel to each other in the same direction, then they

(A) Attract each other

(B) Repel each other

(C) No relation

(D) Neither attracts nor repel.

12. A rectangular coil carrying current is placed in a non-uniform magnetic field. On the coil the total

(A) force is non-zero (B) force is zero (C) torque is zero (D) none of these

13. A conducting circular loop of radius r carries a constant current I. It is placed in a uniform magnetic field B, such that B is perpendicular to the plane of the loop. The magnetic force acting on the loop is

(A) Ir^2B (B) $2\pi rIB$ (C) Zero (D) πr^2IB

14. In a moving coil galvanometer the deflection (Φ) on the scale by a pointer attached to the spring is

(A) $\left(\frac{NA}{kB}\right)I$ (B) $\left(\frac{N}{kAB}\right)I$ (C) $\left(\frac{NAB}{k}\right)I$ (D) $\left(\frac{NAB}{kI}\right)$

15. Resistance of an ideal ammeter is

(A) Infinity (B) 100 Ω (C) Zero (D) 1 Ω

16. A charged particle moves in a gravity free space without change in its velocity. Which of the following is not possible?

(A) $E = 0, B = 0$ (B) $E \neq 0, B = 0$ (C) $E = 0, B \neq 0$ (D) $E \neq 0, B \neq 0$

17. A positive charge is moving in combined gravitational and magnetic field. The charge moves without any change in velocity. If the velocity of charge is along east, then the direction of magnetic field is along

(A) North (B) South (C) Upwards (D) Downwards

18. A charge *q*, mass *m* is moving in uniform circular motion under action of a magnetic field *B*. If the radius of circle is '*R*', then the magnetic moment associated with the charge is given by

(A) $\frac{qBR}{2}$ (B) qBR (C) $\frac{q^2BR^2}{2m}$ (D) $\frac{q^2BR^2}{m}$

19. Statement I: A current carrying wire is placed parallel to magnetic field. The force on it due the magnetic field is zero.

Statement II: The net charge on current wire is zero.

(A) Both Statements I and Statement II are true and the Statement II is a correct explanation of the Statement I.

(B) Both Statements I and Statement II are true but Statement II is not a correct explanation of the Statement I.

(C) Statement I is true but the Statement II is false.

(D) Statement I and Statement II both are false.

20. Match the physical quantities of Column I with their units in Column II

Column I	Column II
(i) Current Sensitivity	(a) Am^{-1}
(ii) Intensity of Magnetic Field	(b) Am^2
(iii) Magnetic Dipole Moment	(c) div A^{-1}

(A) (i)-(c), (ii)-(b), (iii)-(a) (B) (i)-(c), (ii)-(a), (iii)-(b)

(C) (i)-(a), (ii)-(c), (iii)-(b) (D) (i)-(b), (ii)-(a), (iii)-(c)

21. An ammeter and a milli-ammeter are converted from identical galvanometers. Which one has smaller resistance?

(A) Ammeter (B) Milliammeter (C) Both have equal resistances

(D) The resistance of ammeter may be more than or equal to that of milli-ammeter depending upon its range

FILL IN THE BLANKS:

(***Ampere's circuital law, infinity, Lorentz force, Laplace's law, Right hand thumb rule, magnetic dipole***)

1. When the charged particles move in a combined magnetic and electric field, then the force acting is known as _________.

2. The direction of the magnetic field due to a current loop is found using the_________.

3. The alternative form of Biot-Savart's law is ________.

4. Current carrying circular coil is equivalent to _________.

5. Resistance of an ideal voltmeter is _________.

TWO MARK QUESTIONS:

1. Write the expression for magnetic force acting on a charged particle moving in a uniform magnetic field and explain the terms.

2. When is the force on a charged particle moving in a magnetic field (a) maximum and (b) minimum?

3. Does a moving charge always experience a force in a magnetic field? Explain.

4. A proton and an electron enter a magnetic field at the same angle and with the same speed. Do they experience the same force? Justify your answer.

5. What is Lorentz force? Write the expression representing this force.

6. Is any work is done by a magnetic field on a moving charge? Justify your answer.

7. Does a charged particle gain kinetic energy as it enters a magnetic field? Justify your answer.

8. Write the expression for the force acting on a current carrying conductor in a magnetic field and explain the terms.
9. When is the force on a conductor carrying current in a magnetic field (a) maximum and (b) minimum?
10. Write the expression for radius of circular path described by a charged particle in a uniform magnetic field and explain the terms.
11. A proton and an electron moving with the same momentum enter a magnetic field at right angles to it. Compare the radii of their trajectory.
12. Write the expression for angular frequency of a charged particle moving in a uniform transverse magnetic field and explain the terms.
13. Write the expression for the pitch of the helical path traced by an electron in a uniform magnetic field and explain the terms.
14. Write the vector form of Biot-Savart's law and explain the terms.
15. Write the expression for magnetic field at a point due to current element and explain the terms.
16. When is the magnetic field at a point due to a current element (1) maximum and (2) minimum?
17. Write the expression for the magnet field produced at a point on the axis of circular current loop and explain the terms.
18. How will magnetic field strength at the center of the circular current loop change, if the current through the coil is halved and radius of the loop is doubled?
19. State and explain Ampere's circuital law.
20. Write the expression for magnetic field at a point due to long straight current carrying conductor and explain the terms.
21. How does the magnetic field at a point due to straight long current carrying conductor vary with the (a) strength of the current and (b) Perpendicular distance of the point from the conductor.
22. Write an expression for magnetic field at a point inside current carrying solenoid and explain the terms.
23. Mention the factors on which the magnetic fields at a point inside a solenoid depend.
24. How does the magnetic field at a point inside an air cored solenoid vary with the (i) number turns per unit length and (ii) strength of a current though the solenoid.
25. Write the expression for the force between two long straight parallel conductors carrying currents and explain the terms.
26. What is the nature of the force between two parallel conductors carrying currents in the (a) same direction and (b) opposite direction?
27. Define 'ampere' the S.I unit of current by writing the expression for force between two parallel currents.
28. How does the force between the conductors carrying currents vary with (a) strength of current in the conductor and (b) the distance between the conductors?
29. When is the torque on a current loop in magnetic field (i) maximum and (ii) minimum?
30. Write an expression for angular deflection produced by a coil in moving coil galvanometer and explain the terms.
31. Draw a neat labeled diagram of moving coil galvanometer.
32. What is the significance of radial magnetic field in a moving coil galvanometer?
33. What is the role of soft iron cylinder inside the coil in a moving coil galvanometer?
34. Define current sensitivity of a moving coil galvanometer. Mention its SI unit.
35. Define figure of merit of a moving coil galvanometer. Mention its SI unit.
36. Define voltage sensitivity of a moving coil galvanometer. Mention its SI unit.
37. Why an ammeter is always connected in series with a circuit?
38. Why should an ammeter have low resistance?
39. Why a voltmeter is always connected in parallel with a circuit?
40. Why should a voltmeter have high resistance?

41. A proton is moving with a velocity of 5×10^6 ms^{-1} in a direction perpendicular to a magnetic field of strength 0.1 T. Find the force on the proton. Charge on proton = 1.6×10^{-19} C. **[8×10^{-14} N]**
42. A solenoid has 1000 turns/m. A current of 5 A in flowing through it. Calculate the magnetic field inside the solenoid. **[6.2×10^{-3} T]**
43. A moving coil galvanometer has various particulars as n = 30, B = 0.25 T, A = 1.5×10^{-3} m² and k=10^{-3} N-m/deg. Determine the current sensitivity of the galvanometer. **[11. 25 deg/A]**

THREE MARK QUESTIONS:

1. Briefly describe Oersted's experiment leading to the discovery of magnetic effect of current.
2. On what factors the force experienced by a charged particle moving in a magnetic field depends?
3. Write the three features observed at the interaction of a charged particle in the presence of both the electric field and the magnetic field.
4. Derive the expression for the force acting on a conductor carrying current in a uniform magnetic field.
5. What is the nature of trajectory of a charged particle in a uniform magnetic field with initial velocity at an angle (i) 0° (ii) 90° and (iii) in between 0° and 90°, with the direction of the magnetic field?
6. Obtain the expression for radius of circular path described by a charged particle in a uniform magnetic field.
7. Obtain the expression for the angular frequency of a charged particle moving in a uniform transverse magnetic field.
8. What is pitch of helical path traversed by a charge particle moving in a uniform magnetic field? Obtain an expression for it.
9. State and explain of Biot-Savart's law.
10. Give any three comparative differences between Biot-Savart's law for magnetic field and Coulomb's law for electrostatic field.
11. Assuming the expression for the magnetic field at a point on the axis of a circular current loop, obtain the expression for the magnetic field at the center of the loop.
12. Derive the expression for the magnetic field due to a straight infinite current carrying wire using Ampere's circuit law.
13. Explain the magnetic dipole moment of a current loop.
14. Explain how a circular current loop behaves as a magnetic dipole.
15. Explain how to convert a galvanometer into an ammeter.
16. Explain how to convert a galvanometer into a voltmeter.
17. Write any three factors on which the current sensitivity of a moving coil galvanometer depends.
18. Write any three factors on which the voltage sensitivity of a moving coil galvanometer depends.
19. Mention any three ways to increase the current sensitivity of moving coil galvanometer?
20. Mention any three ways to increase the voltage sensitivity of moving coil galvanometer?
21. Does the increase in current sensitivity increase voltage sensitivity? Explain.
22. Mention any three differences between ammeter and voltmeter.
23. A straight wire of mass 200 g and length 1.5 m carries a current of 2 A. It is suspended in mid-air by a uniform horizontal magnetic field. Calculate the magnitude of the magnetic field. **[0.65 T]**
24. A horizontal overhead power lines carries a current of 90 A in east to west direction. What is the magnitude and direction of the magnetic field due to the current 1.5 m below the line? **[1.2×10^{-5} T towards south]**
25. A current loop of area 20 × 10-4 m² carrying a current 0.2 A is placed at an angle of 60° with a magnetic field of strength 4×10^{-2} T. Calculate the torque exerted on it.

FIVE MARK QUESTIONS:

1. Derive the expression for magnetic field at a point on the axis of a circular current loop.
2. Derive the expression for the magnetic field at a point inside an air cored long current carrying solenoid by using Ampere's circuital law.
3. Derive the expression for the force between two long straight parallel conductors carrying currents and hence define ampere.
4. Obtain the expression for the torque acting on a rectangular current loop placed in a uniform magnetic field.
5. With neat labeled diagram, explain the working of a moving coil galvanometer. **[OR]** Give the theory of moving coil galvanometer.

6. An electron beam passes through a magnetic field of 2×10^{-3} T and an electric field of 3.4×10^{4} V/m, both acting simultaneously. If the path of an electron remains undeviated, calculate the speed of the electrons. If the electric field is removed, what will be the radius of the circular path? Given, mass of electron = 9.1×10^{-31} kg and charge of electron = 1.9×10^{-19} C. **[1.7×10^{7} m/s, 4.8×10^{-2} m]**
7. A straight wire of length $\frac{\pi}{2}$ m is bent into a circular shape. O is the center of the circle formed and P is a point on its axis which is at a distance 3 times the radius from O. A current of 1 A is passed through it. Calculate the magnitude of the magnetic field at the points O and P. **[2.5×10^{-6} T, 0.0079×10^{-5} T]**
8. Two circular coils of mean radii 0.1 m and 0.05 m consisting of 5 turns and 10 turns respectively are arranged concentric to one another with their planes at right angles to each other. If a current of 2 A is passed through each of them, calculate the magnitude of the resultant magnetic field at their common centre. **[25.89×10^{-5} T]**
9. Two straight parallel conductors of 2 m length are 0.2 m apart. Find the magnitude of the force acting on the conductors if a current of 3 A flows through each of them. Also find the force per unit length of the conductor. **[18×10^{-6} N, 9×10^{-6} N]**
10. A rectangular coil of length 0.25 m and breadth 0.1 carrying a current 12 A is placed with its longer side parallel to a long straight conductor 0.02 m apart carrying a current of 20 A. Calculate the net force on the coil. **[5×10^{-4} N]**
11. A galvanometer of resistance 50 Ω requires a current of 2 mA for full scale deflection. How do you convert it into (a) an ammeter of range 0 - 3 A and (b) a voltmeter of range 0 - 5 V.
[(a) S = 3.335×10^{-2} Ω, (b) R = 2450 Ω]

ANSWER KEYS TO MULTIPLE CHOICE QUESTIONS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
B	C	D	B	C	A	C	A	C	D	B	A	C	C	C	B	A	C	B	B	A

ANSWERS TO FIBS:

1. Lorentz force 2. Right hand thumb rule 3. Ampere's circuital law 4. magnetic dipole 5. infinity

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5. MAGNETISM AND MATTER

MULTIPLE CHOICE QUESTIONS:

1. **Consider the following statements:**
Statement – I: Magnetic field lines do not intersect each other.
Statement _ II: If the magnetic field lines intersect, the magnetic field would not be unique at the point of intersection.
With reference to the above statements:
(A) both statement - I and statement - II are true and statement - II is the correct explanation of the statement - I.
(B) both statement - I and statement - II are true and statement - II is not correct explanation of the statement - I.
(C) statement - I is true and statement - II is false.
(D) both statement – I and statement – II are false.

2. **When the angle between the magnetic moment of a small compass needle and the uniform magnetic field in which it is placed is θ = 180°:**
(A) the torque on the needle is maximum. (B) the needle is in stable equilibrium.
(C) the potential energy of the needle is zero. (D) the needle in unstable equilibrium.

3. **A magnetized needle placed in a uniform magnetic field, in general, experiences:**
(A) both force and a torque. (B) a force but no torque.
(C) a torque but no force. (D) neither a force nor a torque.

4. **When freely suspended, a magnet comes to rest in the direction:**
(A) North- South (B) East –West (C) South – East (D) South – West

5. **According to Gauss law in magnetism:**
(A) magnetic flux through a closed surface may be non-zero.
(B) magnetic monopoles do not exist.
(C) there can be sources or sinks of magnetic field.
(D) the magnetic flux through any surface is zero..

6. **The dimensional formula for magnetic intensity is:**
(A) [LA] (B) $[L^{-1}A]$ (C) $[LA^{-1}]$ (D) $[L^{-1}A^{-1}]$

7. **If the magnetic susceptibility of a material is 100, its relative permeability is:**
(A) 100 (B) 99 (C) 101 (D) 10

8. **For which one of the following substances, the magnetic susceptibility low and positive?**
(A) Bismuth (B) Copper (C) Iron (D) Sodium

9. **In the following table, column – I lists magnetic substances and column – II lists some magnetic properties of substances.**

COLUMN – I	COLUMN – II
(a) Diamagnetic Substances	(p) $\mu < \mu_o$
(b) Paramagnetic substances	(q) Domain formation
(c) Ferromagnetic substances	(r) $\chi_m > 1$

The best match between column – I and column – II is:
(A) (a) → (p), (b) → (q), (c) → (r) (B) (a) → (p), (b) → (r), (c) → (q)
(C) (a) → (q), (b) → (r), (c) → (p) (D) (a) → (r), (b) → (p), (c) → (q)

10. **The atoms in which kind of magnetic materials have permanent magnetic dipole moment?**
(A) only diamagnetic substances (B) only paramagnetic substances
(C) only ferromagnetic substances (D) both para- and ferromagnetic substances

11. Which magnetic property is a strong effect?

(A) Paramagnetism (B) Diamagnetism

(C) Ferromagnetism (D) Both paramagnetism and ferromagnetism

12. If a magnetic substance is kept in a magnetic field, then which of the following substance moves out of the magnetic field?

(A) Diamagnetic substance (B) Paramagnetic substance

(C) Ferromagnetic substance (D) Both diamagnetic & paramagnetic substance

13. The ratio between magnetization and magnetic intensity:

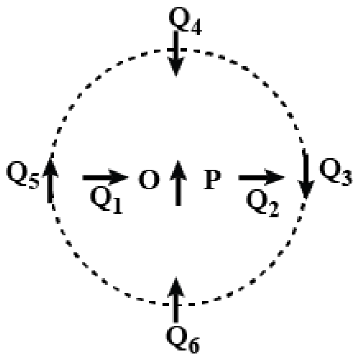
(A) is called permeability (B) is called relative permeability

(C) is a dimensionless quantity (D) is the reciprocal of susceptibility

14. A compass needle of magnetic moment *m* is placed in a uniform magnetic field of *B* such that the angle between them is θ. The ratio magnitude of the torque on the needle to the potential energy of the needle is proportional to:

(A) $\sin\theta$ (B) $\cos\theta$ (C) $\tan\theta$ (D) $\sec\theta$

15. The following figure shows a small magnetized needle P placed at a point O. The arrow shows the direction of its magnetic moment. The other arrows show different positions (and orientations of the magnetic moment) of another identical magnetized needle Q.



Which one of the following statements is false for the above configuration?

(A) In configurations PQ_1 and PQ_2, the system is not is not in equilibrium.

(B) The system will be stable equilibrium for configurations PQ_3 and PQ_6.

(C) The system will be unstable equilibrium for configurations PQ_4 and PQ_5.

(D) PQ_6 corresponds to maximum potential energy state among the given configurations.

16. Needles N_1, N_2 and N_3 are made of a ferromagnetic, a paramagnetic and a diamagnetic substance respectively. A magnet when brought close to them will:

(A) Attract N_1 strongly but repel N_2 and N_3 weakly. (B) Attract N_1 and N_2 strongly but repel N_3

(C) Attract N_1 strongly, N_2 weakly & repel N_3 weakly (D) Attract all 3 of them

FILL IN THE BLANKS:

(*perfect-diamagnetic, paramagnetic, diamagnetic, ferromagnetic, non-magnetic*, *hard ferromagnetic*)

1. _________ property is present in all materials.

2. When a material is placed in a magnetic field, the field inside it is slightly enhanced. The material is a _____________ substance.

3. A substance has a relative permeability of 1000. The material is _____________.

4. Super-conductors show ___________ behavior.

5. In some materials the magnetization persists even after the external field is removed. Such materials are called ___________ substances.

TWO MARK QUESTIONS:

1. Write any two properties of a bar magnet.

2. Can two magnetic field lines intersect each other? Justify your answer.

3. Write the expression for the potential energy of a dipole placed in a uniform magnetic field. Explain the terms.
4. When is the potential energy of a dipole in placed in a uniform magnetic field (i) minimum (ii) maximum?
5. What are the conditions for (i) stable equilibrium and (ii) unstable equilibrium of a compass needle in terms of its magnetic moment and the uniform magnetic field?
6. Write the expression for the torque on small magnetic needle in a uniform magnetic field. Explain the terms.
7. Mention the two differences between Gauss law in magnetism and Gauss law in electrostatics.
8. Define magnetization of a magnetic material. Mention its S.I unit
9. Define magnetic intensity. Give its S.I unit.
10. Define susceptibility of a substance. How are susceptibility and relative permeability related to each other?
11. What is diamagnetism? Give an example of a diamagnetic material.
12. What is Meissner effect? Which materials show this property?
13. Which materials show perfect diamagnetism? What is the value of magnetic susceptibility for such substances?
14. What is paramagnetism? Give an example of a paramagnetic material.
15. Mention any two properties on which paramagnetic susceptibility of a paramagnetic substance depends.
16. Draw the behavior of magnetic field lines near a (i) diamagnetic (ii) paramagnetic substance.
17. What is ferromagnetism? Give an example of a ferromagnetic material.
18. Write any two differences between paramagnetic and ferromagnetic substances.
19. What are domains? What happens to the domain structure at large temperatures?
20. What are hard ferromagnets? Give an example.
21. What are soft ferromagnets? Give an example.
22. The magnetic susceptibility of a ferromagnetic substance is 1499. Find the relative permeability and permeability of the substance. **(1500, 1.88×10^{-3} H m^{-1})**
23. A short bar magnet placed with its axis at 30° with a uniform external magnetic field of 0.25 T experiences a torque of magnitude equal to 4.5×10^{-2} Nm. What is the magnitude of magnetic moment of the magnet? **(0.36 JT^{-1})**
24. A short bar magnet of magnetic moment m = 0.32 JT^{-1} is placed in a uniform magnetic field of 0.15 T. What is the potential energy of the magnet in (i) its stable equilibrium position and (ii) its unstable equilibrium position? **(– 48 mJ, 48 mJ)**
25. A closely wound solenoid of 800 turns and area of cross section 2.5×10^{-4} m^2 carries a current of 3.0 A. What is its associated magnetic moment? **(0.60 JT^{-1})**

THREE MARK QUESTIONS:

1. Mention any three properties of magnetic field lines.
2. State and explain Gauss's law in magnetism. Write its significance.
3. Derive the expression for magnetic potential energy of a dipole placed in a uniform magnetic field.
4. List any three properties of diamagnetic materials.
5. Write any three properties of paramagnetic materials.
6. Mention any three properties of ferromagnetic materials.
7. Differentiate between diamagnetic and paramagnetic materials.
8. Write any three differences between diamagnetic and ferromagnetic materials.
9. A solenoid has a core of a material with relative permeability 400. The windings of the solenoid are insulated from the core and carry a current of 2 A. If the number of turns is 1000 per metre, calculate (a) the magnetic intensity H, (b) magnetization, M, and (c) the magnetic field inside the material B. **(2×10^3 A/m, 8×10^{-5} A/m, 1.0 T)**

10. A bar magnet of magnetic moment 1.5 J T^{-1} lies aligned with the direction of a uniform magnetic field of 0.22 T. What is the amount of work required by an external torque to turn the magnet to align its magnetic moment: (i) normal to the field direction, (ii) opposite to the field direction? **(0.33 J, 0.66 J)**

11. A closely wound solenoid of 2000 turns and area of cross-section 1.6×10^{-4} m^2, carrying a current of 4.0 A, is suspended through its centre allowing it to turn in a horizontal plane.
(a) What is the magnetic moment associated with the solenoid? (b) What is the force and the magnitude of the torque on the solenoid if a uniform horizontal magnetic field of 7.5×10^{-2} T is set up at an angle of 30° with the axis of the solenoid? **(1.28 Am^2, Zero, 0.048 Nm)**

ANSWER KEYS MULTIPLE CHOICE QUESTIONS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
A	D	C	A	B	B	C	D	B	D	C	A	C	C	D	C

ANSWERS TO FIBS:

1. *Diamagnetic, 2. Paramagnetic, 3. Ferromagnetic, 4. Perfect-diamagnetic, 5. Hard ferromagnetic*

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6. ELECTROMAGNETIC INDUCTION

MULTIPLE CHOICE QUESTIONS:

1. The SI unit of magnetic flux is:
(A) T (B) T m^{-2} (C) Wb m^{-2} (D) Wb

2. Consider the following statements:
Statement – I: Lenz law gives the polarity of induced emf in a circuit.
Statement – II: Lenz law is in accordance with the law of conservation of energy.
Between the given two statements:
(A) both are true (B) Only statement – I is true.
(C) only statement – II is true (D) both are false.

3. In electromagnetic induction, the induced e.m.f. in a coil is independent of:
(A) change in the magnetic flux (B) time of change of magnetic flux
(C) resistance of the circuit (D) number of turns in the coil

4. An emf is induced across the ends moving conductor coil in a magnetic field. This is in accordance with:
(A) Ampere's law (B) Gauss law in electrostatics
(C) Gauss law in magnetism (D) Faraday's law

5. The dimensional formula of inductance is:
(A) $[ML^2T^2A^{-2}]$ (B) $[ML^2T^{-2}A^{-2}]$ (C) $[ML^2T^{-2}A^2]$ (D) $[ML^2T^2A^2]$

6. Inductance of a coil is independent of:
(A) the geometry of the coil. (B) the medium inside the coil.
(C) the current through the coil. (D) the number of turns in the coil.

7. The phenomena of induction of an emf in a coil due to change in current through the same coil is called:
(A) Mutual induction (B) Self induction
(C) Motional emf (D) induction of magnetic field.

8. Which physical quantity plays the role of electrical inertia?
(A) Motional emf (B) Mutual-inductance (C) Induced current (D) Self-inductance

9. If the current flowing through a coil is doubled, the magnetic energy stored by it:

(A) is also doubled. (B) becomes halved.

(C) becomes four times. (D) becomes one-fourth the initial value.

10. Match column – I with appropriate options in column – II.

COLUMN – I	COLUMN – II
(a) Self-induced emf	**(p) Motional emf**
(b) EMF induced in a rod moving in a magnetic field	**(q) Electromagnetic induction by changing the orientation of the loop.**
(c) AC generator	**(r) Mutual induction**
(d) Transformer	**(s) Back emf**

(A) (a) → (s); (b) → (p); (c) → (q); (d) → (r) (B) (a) → (r); (b) → (p); (c) → (q); (d) → (s)

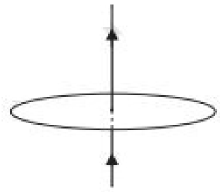
(C) (a) → (p); (b) → (q); (c) → (r); (d) → (s) (D) (a) → (s); (b) → (p); (c) → (r); (d) → (q)

11. In an ac generator, when the plane of the armature is parallel to the magnetic field,

(A) both the magnetic flux and emf are maximum. (B) both magnetic flux and emf are zero.

(C) the magnetic flux is zero and emf is maximum. (D) magnetic flux is maximum and emf is zero

12. The figure shows a long straight current carrying wire placed along the axis of a circular conducting ring. When viewed from above:



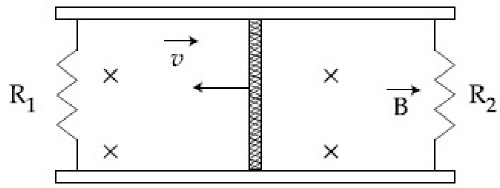
(A) the induced current in the ring is clockwise if the current through the wire is increasing.

(B) the induced current in the ring is anticlockwise if the current through the wire is increasing.

(C) the induced current in the ring is clockwise if the current through the wire is decreasing.

(D) there is no induced current in the ring even when the current through the wire is changing.

13. The following figure shows a conducting rod moving towards left on a rectangular conduction loop. The whole setup is placed in a perpendicular magnetic field pointing into the plane of the paper as shown.



(A) The direction of induced current in the left part is anticlockwise and in the right part is clockwise.
(B) The direction of induced current in the left part is clockwise and in the right part is anticlockwise.
(C) The direction of induced current in both the parts is anticlockwise.
(D) There is no induced current in the left part.

14. If the angular speed of the rotating armature of an ac generator is increased:

(A) the frequency of ac increases while the peak emf remains the same.

(B) the peak emf increases while the frequency of ac remains the same.

(C) both the frequency of ac and the maximum emf increase.

(D) both the frequency of ac and the maximum emf remain the same.

15. Consider the following two statements:

<u>STATEMENT – I:</u> When two coils are wound on each other, the mutual induction between the coils is maximum.

<u>STATEMENT – II:</u> Mutual induction does not depend on the orientation of the coils.

Between the two statements:

(A) Statement – I is false and statement – II is true. (B) Both statements are true.

(C) Statement – I is true and statement – II is false. (D) Both statements are false.

FILL IN THE BLANKS:

(***increases, remains the same, decreases, electric field, magnetic field, becomes zero***)

1. According to the phenomena of electromagnetic induction, a time varying magnetic field induces _____.

2. As the speed of a conducting rod moving perpendicular to a uniform magnetic field decreases, the motional emf induced across it ___________.

3. If the current through a coil increases, its self-inductance _____________.

4. When an iron rod is inserted inside a coil, its self-inductance ____________.

5. A current carrying coil stores energy in the form of ___________.

TWO MARK QUESTIONS:

1. Define magnetic flux through a surface. Give its mathematical formula in vector form.

2. An area A is placed in a uniform magnetic field such that the plane is making an angle θ with the field. For what angle θ, is the magnetic flux through the surface (a) maximum (b) minimum?

3. State and explain Faraday's law of electromagnetic induction.

4. State and explain Lenz's law in electromagnetic induction.

5. Using Lenz law, mention the polarity of the induced emf in a circular coil when a magnet is moved towards and away from the coil.

6. What is motional emf? Write the expression for it.

7. Give the expression for mutual inductance induced between two co-axial solenoids and explain the terms.

8. Mention an expression for self-inductance of a coil and explain the terms.

9. Draw a neat-labeled diagram of AC generator.

10. The magnetic flux linked with a coil changes from 5×10^{-3} Wb to 3×10^{-3} Wb in 0.01 second. Calculate the magnitude of the induced emf in the coil. **(0.2 V)**

11. A wheel with 10 metallic spokes each 0.5 m long is rotated with a speed of 120 revolutions per minute in a plane normal to the horizontal component of earth's magnetic field 0.4×10^{-4} T. What is the induced emf between the axle and the rim of the wheel? **(6.28×10^{-5} V)**

12. The pedals of a stationary bicycle are attached to a 100-turn coil of area 0.10 m^2. The coil rotates at half a revolution per second and it is placed in a uniform magnetic field of 0.01 T perpendicular to the axis of rotation of the coil. What is the maximum voltage generated in the coil? **(0.314 V)**

13. A vertical copper disc of diameter 20 cm makes 10 revolutions per second about a horizontal axis passing through its center. A uniform magnetic field 10^{-2} T acts perpendicular to the plane of the disc. Calculate the potential difference between its center and rim. **(3.14×10^{-3} V)**

14. The electric current in a coil of self-inductance 0.05 H changes from + 2 A to – 2 A in a time interval of 0.1 s. Find the magnitude of the induced emf in the coil. **(2 V)**

15. Current in a circuit falls from 5.0 A to 0.0 A in 0.1 s. If an average emf of 200 V induced, give an estimate of the self-inductance of the circuit. **(4 H)**

16. A pair of adjacent coils has a mutual inductance of 1.5 H. If the current in one coil changes from 0 to 20 A in 0.5 s, what is the change of flux linkage with the other coil? Assume no leakage of magnetic flux. **(30 Wb)**

17. A coil of self-inductance stores an energy of 3.75 J when it carries a current of 5 A. Find the self-inductance of the coil. **(0.3 H)**

THREE MARK QUESTIONS:

1. Describe Faraday's coil and magnet experiment to demonstrate the phenomena of electromagnetic induction.

2. Explain Faraday's coil and coil experiment to demonstrate the phenomena of electromagnetic induction when there is a relative motion between the coils.

3. Derive the expression for motional emf in a conducting rod moving in uniform magnetic field.

4. Obtain the expression for co-efficient of mutual inductance between two co-axial solenoids.

5. Mention any three factors on which the mutual inductance between a pair of coil depends.
6. Derive the expression for the coefficient of self-induction of a coil.
7. Mention any three factors on which the self-inductance of a coil depends.
8. Derive the expression for the emf induced in a coil due to a varying current in the coil.
9. Obtain the expression for energy stored in an inductor.
10. Explain the working of an AC generator with a neat-labeled diagram.
11. The magnetic flux through a coil of 10 turns changes with time as $\phi_B(t) = t^2 - 2t + 4$ Wb. Find the magnitude of the induced emf at $t = 3$ s. **(4 V)**
12. A square loop of side 10 cm and resistance 0.5 Ω is placed vertically in the east-west plane. A uniform magnetic field of 0.10 T is set up across the plane in the north-east direction. The magnetic field is decreased to zero in 0.70 s at a steady rate. Determine the magnitudes of induced emf and current during this time-interval. **(1 mV, 2 mA)**
13. The magnetic field inside a coil of length 0.5 m and area of cross section 100 cm^2 is 1.585×10^{-3} T. What is the magnetic energy density inside the coil? Also, calculate the magnetic energy stored by the coil. **(1 J m^{-3}, 5mJ)**

FIVE MARK QUESTIONS:

1. (a) What is an AC generator?
   (b) What is the principle behind the working of a ac generator.
   (c) Derive an expression for the instantaneous emf generated in n ac generator.
2. A circular coil of radius 10 cm, 500 turns and resistance 2 Ω is placed with its plane perpendicular to the horizontal component of the earth's magnetic field. It is rotated about its vertical diameter through 180° in 0.25 s. Estimate the magnitudes of the emf and current induced in the coil. Horizontal component of the earth's magnetic field at the place is 3.0×10^{-5} T. **(3.8 mV, 1.8 mA)**
3. A long solenoid with 15 turns per cm has a small loop of area 2.0 cm^2 placed inside the solenoid normal to its axis. If the current carried by the solenoid changes steadily from 2.0 A to 4.0 A in 0.1 s, what is the induced emf in the loop while the current is changing? If the loop has a resistance of 5×10^{-3} Ω, what is the power dissipated across it? **(7.5 µV, 1.1×10^{-8} W)**
4. A rectangular wire loop of sides 8 cm and 2 cm with a small cut is moving out of a region of uniform magnetic field of magnitude 0.3 T directed normal to the loop. What is the emf developed across the cut if the velocity of the loop is 1 cm s^{-1} in a direction normal to the (a) longer side, (b) shorter side of the loop? For how long does the induced voltage last in each case? **(0.24 mV, 2 s; 0.6×10^{-4} V, 8 s)**
5. A horizontal straight wire 10 m long extending from east to west is falling with a speed of 5.0 m s^{-1}, at right angles to the horizontal component of the earth's magnetic field, 0.30×10^{-4} Wb m^{-2}.
   (a) What is the instantaneous value of the emf induced in the wire? **(1.5 mV)**
   (b) What is the direction of the emf? **(West to East)**
   (c) Which end of the wire is at the higher electrical potential? **(West end)**

ANSWER KEYS TO MULTIPLE CHOICE QUESTIONS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
D	A	C	D	B	C	B	D	C	A	C	D	B	C	C

ANSWERS TO FIBS:

1. electric Field, 2. decreases,3. remains the same, 4. increases, 5. magnetic field

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7. ALTERNATING CURRENT

MULTIPLE CHOICE QUESTIONS:

1. **Which one of the following statements is wrong?**
(A) AC can be easily and efficiently stepped up or stepped down.
(B) It is economical to transmit dc over large distances.
(C) The average value of sinusoidal alternating current or voltage over a complete cycle is zero.
(D) The average power consumed by a ac circuit over a complete cycle may not be zero.

2. **In a purely capacitive circuit, if the frequency of ac is doubled, the capacitive reactance will:**
(A) get doubled (B) become four times
(C) get halved (D) remain constant.

3. **The phenomena of resonance exhibited by an ac circuit:**
(A) only if both L & C are present in the circuit. (B) only if both L & R are present in the circuit.
(C) only if both R & C are present in the circuit. (D) only R is present in the circuit.

4. **The dimensional formula of LC is (L is self-inductance and C is capacitance)**
(A) [T] (B) $[T^2]$ (C) $[T^{-1}]$ (D) $[T^{-2}]$

5. **The principle behind working of a transformer is:**
(A) Eddy currents (B) Self-induction (C) Mutual induction (D) Hysteresis

6. **The use of laminated core in a transformer reduces energy loss due to:**
(A) flux leakage (B) coil resistance (C) hysteresis (D) Eddy currents

7. **The frequency of ac is increased, the impedance of a series LCR circuit:**
(A) continuously increases (B) continuously decreases
(C) first increases and then decreases (D) first decreases and then increases

8. **Power factor for a purely resistive circuit is:**
(A) zero (B) unity (C) infinity (D) 0.5

9. **At resonance, a series LCR ac circuit behaves like a:**
(A) purely capacitive circuit. (B) purely resistive circuit.
(C) purely inductive circuit (D) LC circuit

10. **The power factor of a series LCR circuit is maximum when:**
(A) $X_L = X_C$ (B) $X_C = 0$ (C) $X_L > X_C$ (D) $X_L < X_C$

11. **At resonance, the voltage across resistance is equal to:**
(A) the voltage across L (B) the voltage across C
(C) the applied voltage (D) the sum of voltages across L & C

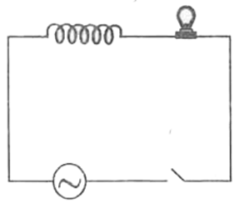
12. **For a transformer, $\frac{N_s}{N_p} = 100$. This means that:**
(A) the output current is 100 times the input current
(B) the transformer is a step-down transformer
(C) the output power is 100 times the input power.
(D) the input current is 100 times the output current.

13. **The column – I lists the component through which alternating current is passed. The column – II lists quantities related column – I. Match column – I with appropriate options form column – II:**

COLUMN – I	COLUMN – II
(a) Pure resistor	**(p) The current leads the voltage by π /2**
(b) Pure capacitor	**(q) The current lags behind the voltage by π /2**
(c) Pure Inductor	**(r) Reactance of the circuit is independent of frequency of ac.**
(d) A series LCR circuit	**(s) average power dissipated over a complete cycle is non-zero.**

(A) (a) → (r); (b) → (q); (c) → (p); (d) → (s) (B) (a) → (r,); (b) → (p); (c) → (q); (d) → (s)
(C) (a) → (s); (b) → (p); (c) → (q); (d) → (r) (D) (a) → (s); (b) → (q); (c) → (p); (d) → (r)

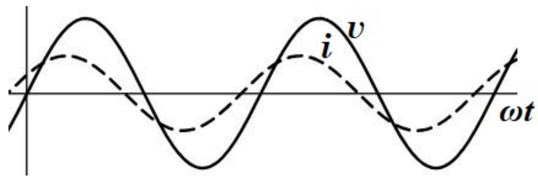
14. **A light bulb and an open coil inductor are connected to an ac source through a key as shown in the figure.**



The switch is closed and after sometime, an iron rod is inserted into the interior of the inductor. As the iron rod is inserted, the glow of the light bulb:

(A) decreases. (B) increases (C) is unchanged (D) may increase or decrease

15. **The following figure represents the variation of voltage and current of an ac with time. The solid line represents the instantaneous voltage while the dashed line represents the instantaneous current.**



From the figure, we can infer that the circuit is:

(A) purely resistive (B) purely inductive.

(C) a series LCR circuit with $X_L > X_C$. (D) a series LCR circuit with $X_L < X_C$

FILL IN THE BLANKS:

(***equal to unity, less than unity, greater than unity, zero, π/2, π***)

1. The phase difference between voltage and current in the case of ac through a pure capacitor is __________.
2. The power factor of a series LCR circuit at resonance is ____________.
3. At resonance of series LCR circuit, the voltage across combination of L and C is ______.
4. In a series LCR ac circuit, the current leads the voltage by π/3. The ratio between the inductive reactance and the capacitive reactance for the circuit is ____________.
5. For a step-down transformer, the ratio of primary current to secondary current is __________.

TWO MARK QUESTIONS:

1. What is the phase difference between the current and the voltage in the case of a (i) purely resistive circuit and (ii) purely capacitive circuit?
2. What is the average power dissipated over a complete cycle of ac in the case of (i) purely resistive circuit (ii) purely inductive circuit?
3. Write any two differences between inductive reactance and capacitive reactance.
4. An AC source of voltage is connected to a resistor. Draw phasor diagram and the sinusoidal voltage – current waveforms for the circuit.
5. An AC source of voltage is connected to an ideal capacitor. Draw phasor diagram and the sinusoidal voltage – current waveforms for the circuit.
6. An AC source of voltage is connected to an ideal inductor. Draw phasor diagram and the sinusoidal voltage – current waveforms for the circuit.
7. What is capacitive reactance? How does it vary with the frequency of ac?
8. What is inductive reactance? How does it vary with the frequency of ac?
9. What is resonance of a series LCR circuit? Mention one application of resonance in series LCR circuits.
10. Draw impedance diagram for a series LCR circuit. Write the expression for the phase difference between the current and the voltage.
11. What is a transformer? What is its working principle?
12. Give any two differences between step- up transformer and step- down transformer.

13. Alternating current is represented by the equation $i = 10\sin(314t)\ A$. Find the value of frequency of AC. **(50 Hz)**

14. The voltage across a resistor varies with time as $v = 100\sin(50t)\ V$. Calculate the value of the rms voltage. **(70.7 V)**

15. Find the capacitive reactance of an ac circuit of frequency 100 Hz. Given C = 32 μF. **(49.8 Ω)**

16. In a inductive ac circuit, the value of inductance is 0.2 H and the frequency of ac is 50 Hz. Calculate the inductive reactance. **(62.84 Ω)**

17. In a series LCR circuit, the rms voltages across L, C and R are 50 V, 10 V and 40 V respectively. What is the value of the input rms voltage? **(50 V)**

18. The phase difference between the voltage and the current in an ac circuit is 60°. Find the phase power factor for the circuit. **(0.5)**

19. Find the resonant frequency for a series LCR circuit with L = 0.5 H and C = 8 μF. **(500 rad s^{-1})**

20. For a series LCR circuit with L = 0.5 H and C = 8 μF and R = 10 Ω. If the applied rms voltage is 50 V, what is the average power dissipated by the circuit at resonance? **(250 W)**

21. The turns ratio in a transformer is 50. If the voltage across the primary of the transformer is 220 V, what is the voltage across its secondary? **(11,000 V)**

22. A power transmission line feeds input power at 2300 V to a step down transformer with its primary windings having 4000 turns. What should be the number of turns in the secondary in order to get output power at 230 V? **(400)**

THREE MARK QUESTIONS:

1. Derive the expression for current in case of AC applied to a pure resistor.

2. Show that the average power over one complete cycle is zero in case of a capacitor connected to AC.

3. Derive the expression for the average power dissipated in a series RLC circuit.

4. What is resonance in LCR series circuit? Obtain the expression for resonant frequency of it.

5. Explain how power is dissipated by writing the expression for power factor in case of (i) pure inductive or capacitive (ii) purely resisitve (iii) series LCR at resonance circuits.

6. Give the construction and working of a transformer.

7. Mention any three sources of energy loss in a transformer.

8. A light bulb is rated at 100W for a 220 V supply. Find (a) the resistance of the bulb; (b) the peak voltage of the source; and (c) the rms current through the bulb. **(484 Ω, 311 V, 0.454 A)**

9. The rms voltage and the rms current through an ac circuit are 50 V and 2 A respectively. If the average power across the circuit is 50 W, what is the phase difference between the voltage and the current?

10. A pure inductor of 25.0 mH is connected to a source of 220 V. Find the inductive reactance and rms current in the circuit if the frequency of the source is 50 Hz. **(7.85 Ω. 28 A)**

11. An L-C-R series circuit is connected to an external emf $\varepsilon = 200\sin 100\pi t$ V. The values of the capacitance and resistance in the circuit are 1 μF and 100 μF respectively. Find the inductance for which current in the circuit is maximum. **(10 H)**

FIVE MARK QUESTIONS:

1. Obtain the expression for current in case of AC applied to an inductor. Show that the current lags behind the voltage by π/2. Draw the phasor diagram and voltage – current waveforms.

2. Derive the expression for current in case of AC applied to a capacitor. Show that the current leads the voltage by π/2. Draw the phasor diagram and voltage – current waveforms.

3. Derive the expression for impedance and hence the current of an RLC series circuit connected to an AC using phasor diagram.

4. A 50 Ω resistor, 0.5 H inductor and 200 μF capacitor are connected in series with 220 V and 50 Hz source. Find the impedance of the circuit and hence the current. **(149.7 Ω, 1.47 A)**

5. A 15.0 μF capacitor is connected to a 220 V, 50 Hz source. Find the capacitive reactance and the current (rms and peak) in the circuit. If the frequency is doubled, what happens to the current?

(212 Ω, 1.04 A, 1.47 A, the current is doubled)

6. A resistor of 200 W and a capacitor of 15.0 mF are connected in series to a 220 V, 50 Hz ac source. (a) Calculate the current in the circuit; (b) Calculate the voltage (rms) across the resistor and the capacitor. **(0.755 A, 151 V, 160.3 V)**

7. A current of 4 A flows in a coil when connected to a 12 V d.c. source. If the same coil is connected to 12 V, 50 Hz a.c. source, a current of 2.4A flows in the circuit. Calculate the self-inductance of the coil. **(80 mH)**

8. A resistance of 10 Ω is connected in series with an inductor of inductance 0.5 H. These two are connected to 200 V, 50 Hz a.c. source. Calculate the capacitance that should be put in series with the combination to obtain the maximum current. Also, find the current through the circuit. **(20.24 µF, 20 A)**

9. A source of 220 V, 40 Hz is connected to a series combination of 6 Ω resistor, 0.01 H inductor. Calculate the phase angle and the power factor of the circuit. **(22.7°, 0.92)**

10. A sinusoidal voltage of peak value 283 V and frequency 50 Hz is applied to a series LCR circuit in which $R = 3\ \Omega$, $L = 25.48$ mH, and $C = 796$ mF. Find (a) the impedance of the circuit; (b) the phase difference between the voltage across the source and the current; (c) the power dissipated in the circuit; and (d) the power factor. **(5 Ω, 53.1°, 40 A, 0.6)**

11. A LCR circuit connected is to a variable frequency 230 V source. $L = 5.0$ H, $C = 80\ \mu$F, $R = 40\ \Omega$. (a) Determine the source frequency that drives the circuit in resonance. (b) Obtain the impedance of the circuit and the amplitude of current at the resonating frequency. (c) Determine the rms potential drops across the three elements of the circuit. (**(a) 50 rad/s; (b) 40Ω, 8.1A; (c) V_L=V_C =1437.5 V, V_R=230 V)**

12. In a step-down transformer having primary to secondary turns ratio 20 : 1, the input voltage applied is 250 V and output current is 8 A. Assuming 100% efficiency calculate (i) voltage across the secondary coil, (ii) current in primary coil (iii) output power. **(12.5 V, 0.4 A, 100 W)**

13. An LCR circuit contains resistance of 100 Ω and supply of 200 V at 300 rad/sec. If only capacitance is taken out from the circuit and the rest of the circuit is joined, current lags behind the voltage by 60°. If on the other hand, only inductor is taken out, the current leads by 60° with applied voltage. Find the current flowing in the circuit. **(2A)**

14. A bulb of 60 V, 10 W is connected with 100 V, 60 Hz ac source with an inductance coil in series. If bulb illuminates with its full intensity then calculate the value of self-inductance of coil. **(1.28 H)**

15. One 80 V, 50 W bulb is to be connected to 100 V, 50 Hz ac line. A suitable capacitor is connected in series with the bulb so that the bulb glows with its full intensity. Find the value of the capacitance of the capacitor. **(33 µF)**

ANSWER KEYS TO MULTIPLE CHOICE QUESTIONS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
B	C	A	B	C	D	D	B	B	A	C	D	B	A	D

ANSWERS TO FIBS:

1. π/2, 2. equal to unity, 3. zero, 4. greater than unity, 5. less than unity

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8. ELECTROMAGNETIC WAVES

MULTIPLE CHOICE QUESTIONS:

1. Displacement current is produced due to

(A) Constant electric field (B) constant magnetic field

(C) Changing electric field (D) changing magnetic field

2. The expression for displacement is

(A) $i_d = \epsilon_0^2 \frac{d\phi_E}{dt}$ (B) $i_d = \mu_0 \in_0 \frac{d\phi_E}{dt}$ (C) $i_d = \mu_0 \frac{d\phi_E}{dt}$ (D) $i_d = \in_0 \frac{d\phi_E}{dt}$

3. Electromagnetic wave theory was proposed by

(A) Michael Faraday (B) Luis de'Broglie (C) J C Maxwell (D) Albert Einstein

4. Choose the false statement.

(A) Electromagnetic waves are produced by accelerated charged particles.

(B) For electromagnetic waves $\frac{E_0}{B_0} = c$ where E_o and B_o are electric and magnetic field amplitudes.

(C) Electromagnetic waves are transverse in nature.

(D) Electromagnetic waves can be deflected by electric field and magnetic field.

5. An electromagnetic wave going through vacuum is described by
***$E = E_0 \sin(kx - \omega t)$, $B = B_0 \sin(kx - \omega t)$* then**

(A) $E_0 B_0 = \omega k$ (B) $E_0 \omega = B_0 k$ (C) $E_0 k = B_0 \omega$ (D) $\frac{E_o}{B_o} = \omega k$

6. Out of the following options which one can be used to produce a propagating electromagnetic wave?

(A) A chargeless particle (B) An accelerating charge

(C) A charge moving at constant velocity (D) A stationary charge

7. Which electromagnetic wave used in long range communication?

(A) Gamma rays (B) IR-rays (C) Radio waves (D) Micro waves

8. The increasing order of wavelength of infrared, microwave, ultraviolet and gamma rays (γ-rays) is

(A) microwave, infrared, ultraviolet, γ- rays (B) γ- rays, ultraviolet, infrared, microwaves

(C) microwaves, γ- rays, infrared, ultraviolet (D) infrared, microwave, ultraviolet, γ- rays

9. The ultraviolet region of the electromagnetic spectrum lies between

(A) x-ray region and visible region (B) gamma ray region and x-ray region

(C) visible region and microwave region (D) IR region and radio wave region

10. The wavelength range of x-rays is

(A) $< 10^{-3}$ nm (B) 1 nm - 10^{-3} nm (C) 400 nm to 1nm (D) 0.1 m to 1 mm

11. The electromagnetic waves suitable for RADAR systems used in aircraft navigation are

(A) Gamma rays (B) Ultraviolet rays (C) Microwaves (D) Infrared waves

12. Statement i: Displacement current goes through the gap between the plates of a capacitor when the charge on the plates of the capacitor does not change.

Statement ii: The displacement current arises in the region in which the electric field is constant with time.

(A) Statements i and ii both are correct and statement ii is a correct explanation for statement i.

(B) Statements i and ii both are correct but statement ii is not correct explanation for statement i.

(C) Statements i is correct but ii is wrong.

(D) Both the statements are wrong.

13. **Statement i: Electromagnetic waves are transverse in nature.**

Statement ii: The electric and magnetic fields in electromagnetic waves are perpendicular to each other and to the direction of propagation.

(A) Statements i and ii both are correct and statement ii is a correct explanation for statement i.
(B) Statements i and ii both are correct but statement ii is not correct explanation for statement i.
(C) Statements i is correct but ii is wrong.
(D) Both the statements are wrong.

14. **Statement i: The velocity of electromagnetic waves depends on electric and magnetic properties of the medium.**
Statement ii: Velocity of electromagnetic waves in free space is constant.
(A) Statements i and ii both are correct and statement ii is a correct explanation for statement i.
(B) Statements i and ii both are correct but statement ii is not correct explanation for statement i.
(C) Statements i is correct but ii is wrong.
(D) Both the statements are wrong.

15. **Statement i: Infrared radiation plays an important role in maintaining the average temperature of earth.**
Statement ii: Infrared radiations are sometimes referred to as heat waves.
(A) Statements i and ii both are correct and statement ii is a correct explanation for statement i.
(B) Statements i and ii both are correct but statement ii is not correct explanation for statement i.
(C) Statements i is correct but ii is wrong.
(D) Both the statements are wrong.

16. **Statement i: Microwaves are used in microwave ovens**
Statement ii: The frequency of microwaves are matched with the resonant frequency of water molecules.
(A) Statements i and ii both are correct and statement ii is a correct explanation for statement i.
(B) Statements i and ii both are correct but statement ii is not correct explanation for statement i.
(C) Statements i is correct but ii is wrong.
(D) Both the statements are wrong.

TWO MARK QUESTIONS:

1. Write the expression for displacement current and explain the terms.
2. Write Ampere-Maxwell's equation and explain the terms.
3. What is displacement current? Write the expression for speed of light in vacuum in terms of permittivity and permeability.
4. Give any two properties of electromagnetic waves.
5. How are electromagnetic waves formed? Explain.
6. Give any two applications of x-rays.
7. Give any two applications of uv-rays.
8. Give any two applications of IR-rays.
9. Give any two uses of micro waves.
10. Mention any two uses of radio waves.
11. Name the electromagnetic waves used for the following applications.
(a) The radar systems used in aircraft navigation.
(b) The remote switches of household electronic systems such as TV.

ANSWER KEYS TO MULTIPLE CHOICE QUESTIONS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
C	D	C	D	C	B	C	B	A	B	C	D	A	B	A	A

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9. RAY OPTICS AND OPTICAL INSTRUMENTS

MULTIPLE CHOICE QUESTIONS:

1. In reflection of light, the angle of reflection is
(A) More than incident angle (B) less than incident angle
(C) Equal to angle of incidence (D) more or less than incident angle

2. Focal length of a spherical mirror depends on
(A) Object distance (B) image distance
(C) both object and image distances (D) radius of curvature

3. When an object is placed at infinity from a spherical mirror, the image is formed at
(A) infinity (B) principal focus (C) at centre of curvature (D) pole

4. The focal length of a spherical mirror is
(A) equal to radius of curvature (B) two times the radius of curvature
(C) half of the radius of curvature (C) not depends on radius of curvature

5. For reflection in spherical mirrors, all distances are measured from the
(A) pole (B) principal focus (C) centre of curvature (D) from object

6. In refraction of light
(A) $\frac{\sin i}{\sin r} = 1$ (B) $\frac{i}{r}$ = constant (C) $\sin i \times \sin r$ = constant (D) $\frac{\sin i}{\sin r}$ = constant

7. For total internal reflection of light
(A) light should travel from rarer medium to denser medium
(B) light should travel from denser medium to rarer medium
(C) light should incident along the normal
(D) the angle of incidence should be equal to 90^{o}.

8. An object of finite height is placed in front of a concave mirror within its focus. It forms
(A) a real enlarged image (B) a real diminished image
(C) a virtual enlarged image (D) a virtual diminished image

9. The speed of light in a medium depends on
(A) angle of incidence (B) angle of refraction
(C) refractive index (D) its mass density

10. Refractive index of a medium depends on
(A) thickness of the medium (B) angle of incidence
(C) mass density of the medium (D) none of above

11. When a light ray travels from rarer medium to denser medium, its
(A) velocity increases (B) velocity decreases
(C) wavelength increases (D) frequency decreases

12. Snell's law fails in the case of
(A) when light travel from denser to rarer (B) oblique incidence
(C) when light travel from rarer to denser (D) normal incidence

13. The principle of optical fibres is
(A) reflection of light (B) refraction of light
(C) dispersion of light (D) total internal reflection

14. The focal length of a lens is depends on
i) refractive index of the material
ii) radii of curvature of two surfaces
iii) diameter of the aperture

(A) only option i) is correct (B) only option i) and ii) are correct
(C) only ii and iii are correct (D) option i, ii and iii are correct

15. Two thin lenses of focal lengths f_1 and f_2 are in contact. The power of the combination is
(A) $\frac{f_1+f_2}{2}$ (B) $\frac{f_1+f_2}{f_1 f_2}$ (C) $\frac{f_1 f_2}{f_1+f_2}$ (D) $\frac{\sqrt{f_1}}{\sqrt{f_2}}$

16. The angle of minimum deviation of a prism is depends on
(A) only angle of the prism (B) only refractive index of the prism
(C) angle of incidence (D) both angle of the prism and its refractive index

17. A ray of light is incident on glass-air interface at an angle greater than the critical angle for the pair of media. Then the ray undergoes
(A) refraction only (B) partial reflection and partial refraction
(C) total internal reflection (D) grazes the surface at the interface of the two media

18. The magnification of a refracting telescope is
(A) $\frac{f_o}{f_e}$ (B) $\frac{f_e}{f_o}$ (C) $f_o + f_e$ (D) $f_o.f_e$

19. A lens of large focal length and large aperture is best suited as an objective of an astronomical telescope since
(A) a large aperture contributes to the quality and visibility of the images.
(B) a large area of the objective ensures better light gathering power.
(C) a large aperture provides a better resolution
(D) all of the above.

20. Statement i: A convex mirror is preferred over a plane mirror in vehicles to observe traffic coming from behind.
Statement ii: Convex mirrors have large field of view and images of real objects formed by convex mirrors are erect.
(A) Statements i and ii both are correct but statement ii is not a correct explanation for statement i.
(B) Statements i and ii both are correct and statement ii is the correct explanation for statement i.
(C) Statements i is correct but ii is wrong.
(D) Statements i is wrong but ii is correct.

21. Statement i: The image forms formed by total internal reflections are much brighter than those formed by mirrors or lenses.
Statement ii: In total internal reflection, the light is completely reflected and there is no loss of intensity of light.
(A) Statements i and ii both are correct and statement ii is correct explanation for statement i.
(B) Statements i and ii both are correct but statement ii is not correct explanation for statement i.
(C) Statements i is correct but ii is wrong.
(D) Both the statements are wrong.

22. Statement i: The focal length of equiconvex lens of refractive index 1.5 placed in air is equal to radius of curvature of either face.
Statement ii: For equi-convex lens radius of curvature of both the faces is same.
(A) Statements i and ii both are correct but statement ii is not a correct explanation for statement i.
(B) Statements i and ii both are correct and statement ii is a correct explanation for statement i.
(C) Statements i is correct but ii is wrong.
(D) Statements i is wrong but ii is correct.

23. Statement i: If a glass prism is immersed in water its angle of minimum deviation is increases.
Statement ii: Angle of minimum deviation of a prism is increases with increase in the refractive index of the prism.
(A) Statements i and ii both are correct but statement ii is not a correct explanation for statement i.

(B) Statements i and ii both are correct and statement ii is a correct explanation for statement i.
(C) Statements i is correct but ii is wrong.
(D) Statements i is wrong but ii is correct.

24. **Statement i: In a simple microscope, the object is placed at distance slightly less than the focal length of the objective lens.**
Statement ii: When the object is placed within the focal point of a convex lens, enlarged, erect image is formed.
(A) Statements i and ii both are correct but statement ii is not a correct explanation for statement i.
(B) Statements i and ii both are correct and statement ii is a correct explanation for statement i.
(C) Statements i is correct but ii is wrong.
(D) Statements i is wrong but ii is correct.

25. **Statement i: In compound microscope, the focal length of objective lens is large whereas the focal length of eyepiece is small.**
Statement ii: The magnification of compound microscope varies inversely to the focal lengths of both objective lens and eye lens.
(A) Statements i and ii both are correct but statement ii is not a correct explanation for statement i
(B) Statements i and ii both are correct and statement ii is a correct explanation for statement i.
(C) Statements i is correct but ii is wrong.
(D) Statements i is wrong but ii is correct.

26. **Statement i: In refracting telescope, the focal length of objective lens is large whereas the focal length of eyepiece is small.**
Statement ii: The magnification of refracting telescope directly proportional to the focal length of objective lens and varies inversely with the focal length of eye lens.
(A) Statements i and ii both are correct and statement ii is a correct explanation for statement i.
(B) Statements i and ii both are correct but statement ii is not correct explanation for statement i.
(C) Statements i is correct but ii is wrong.
(D) Statements i is wrong but ii is correct.

FILL IN THE BLANKS:

(*inversely , normal shift, parallel, critical angle, directly, total internal reflection*)

1. The bottom of a swimming pool appears to be raised above is due to ____________.
2. Optical fibres are working on the principle of ___________.
3. For total internal reflection of light, the angle of incident must be greater than ___________.
4. At minimum deviation position, the refracted ray inside the prism is ________ to the base of the prism.
5. The magnification of compound microscope is ____________ proportional to focal length of eye lens.

TWO MARK QUESTIONS

1. State the laws of reflection.
2. State the laws of refraction.
3. Give the conditions for total internal reflection.
4. Mention the relation between refractive index and critical angle.
5. What are optical fibres? What is the principle of optical fibres?
6. Mention the factors on which focal length of a lens depends.
7. Define power of the lens and give its SI unit.
8. Write the expression for refractive index of the prism in terms of angle of the prism and angle of minimum deviation.
9. Draw the ray diagram of image formation in simple microscope when the object is at near point.
10. Draw the ray diagram of image formation in simple microscope when the object is at infinity.

11. Write the expression for magnification of the image formed in simple microscope.
12. Draw the ray diagram of image formation in compound microscope.
13. Write the expression for magnification of the image formed in compound microscope.
14. Draw the ray diagram of image formation in refracting telescope.
15. Write the expression for magnification of the image formed in refracting telescope.
16. An object is placed at a distance of 25 cm from a concave mirror of focal length 15 cm. Find the position of image formed.

THREE MARK QUESTIONS:

1. Give the sign conventions used in geometric optics.
2. Prove that, the focal length of a spherical mirror is half of its radius of curvature.
3. Give any three applications of optical fibres.
4. A small telescope has an objective lens of focal length 144cm and an eye piece of focal length 6 cm. What is the magnifying power of the telescope?

FIVE MARK QUESTIONS:

1. Derive the mirror equation $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$.
2. Derive the relation $-\frac{n_1}{u} + \frac{n_2}{v} = \frac{n_2 - n_1}{R}$ for a refraction through a spherical surface where symbols having their usual meaning. **(OR)**
   Derive the relation connecting *n*, *u*, *v* and *R* for refraction through a spherical surface.
3. Derive Lens maker's formula.
4. Obtain the expression for equivalent focal length of a combination of two thin lenses in contact.
5. Obtain the expression for refractive index of a prism in terms of angle of the prism A and angle of minimum deviation D. **(OR)**
   Derive the expression $n = \frac{\sin\frac{A+D}{2}}{\sin\frac{A}{2}}$ where symbols having their usual meaning.
6. An object is placed at a distance of 40 cm from a concave mirror of focal length 15 cm. If the object is displaced through a distance of 20 cm towards the mirror, by how much distance is the image displaced? **(36 cm)**
7. A small bulb (a point source) is placed at the bottom of a tank containing water to a depth of 80 cm. What is the radius of the circular surface of water through which light emerge out? Refractive index of water is 1.33. **(91 cm)**
8. The radii of curvature of two surfaces of a convex lens is 0.2 m and 0.22 m. Find the focal length of the lens if refractive index of the material of the lens is 1.5. Also find the change in focal length, if it is immersed in water of refractive index 1.33. **(f = 21 cm, Δf = 61 cm)**
9. Double convex lens is to be manufactured from a glass of refractive index 1.52, with both faces of same radius of curvature. What is the radius of curvature required if the focal length is 25 cm. What will be new focal length when the lens is immersed in water of refractive index 1.33. **(R= 26 cm, f_w = 91 cm)**
10. An object of height 3 cm is placed 14 cm in front of a concave lens of focal length 21 cm. Find the position, nature and size of the image formed. **(v = + 42 cm, virtual image, 9 cm in height)**
11. Two lenses of focal length 0.2 m and 0.3 m are kept in contact. Find the focal length of the combination, Calculate powers of two lenses and combination. **(F = 0.12 cm, P_1 = 5 D, P_2 = 3.3 D, P = 8.3 D)**
12. A prism of angle 60˚ produces angle of minimum deviation of 40˚. What is its refractive index? Calculate the angle of incidence. **(*n* = 1.53, *i* = 50^o)**
13. A ray of light is incident at 40^o on one face of an equilateral prism of refractive index 1.55. Calculate the angle of deviation as it emerges from the other surface. **(44^o10')**
14. An equilateral prism is made of glass. When a beam of light is incident on a face of the prism the angle of minimum deviation is found to be 40^o. Calculate the refractive index of the prism. If this prism is immersed in water of refractive index 1.33, find the new angle of minimum deviation. **(n = 1.53, D = 10.2^o)**

ANSWER KEYS TO MULTIPLE CHOICE QUESTIONS:

1	2	3	4	5	6	7	8	9	10	11	12	13
C	D	B	C	A	D	B	C	C	D	B	D	D
14	15	16	17	18	19	20	21	22	23	24	25	26
B	B	D	C	A	D	B	A	A	D	B	D	A

ANSWERS TO FIBS:

1. Normal shift, 2. Total internal reflection, 3. Critical angle, 4. Parallel, 5. Inversely proportional

****

10. WAVE OPTICS

MULTIPLE CHOICE QUESTIONS:

1. **Wave theory of light is proposed by**
   (A) Isaac Newton (B) Christiaan Huygens (C) Foucault (D) Snell
2. **According to Huygen's principle, the speed of the secondary wavelets is**
   (A) Twice that of the wave (B) zero
   (C) same as the wave (D) infinite
3. **To observe sustained interference pattern on a screen placed at a suitable distance in Young's double slit experiment, which of the following condition/s is/are necessary?**
   (i) Sources of light should be coherent.
   (ii) Sources of light should be narrow.
   (ii) Sources of light should be very close.
   (A) only (i) (B) both (i) and (ii) (C) both (ii) and (iii) (D) all (i), (ii) and (iii)
4. **Two light sources are said to be coherent when both the sources of light emit light of**
   (A) The same amplitude and phase (B) The same intensity and wavelength
   (C) The same speed (D) The same wavelength and constant phase difference
5. **In Young's double-slit experiment with monochromatic light, how is fringe width affected, if the screen is moved closer to the slits?**
   (A) Independent (B) Remains the same (C) Increases (D) Decreases
6. **What would be the resultant intensity at a point of destructive interference, if there are two identical coherent waves of intensity I_0 producing an interference pattern?**
   (A) 5 I_0 (B) 2 I_0 (C) zero (D) I_0
7. **Diffraction effect is exhibited by ________.**
   (A) only sound waves (B) only light waves (C) only matter waves (D) all types of waves
8. **In single slit diffraction experiment, the width of the slit is made double of its original width. Then the central maximum of the diffraction pattern will become**
   (A) narrower and fainter (B) narrower and brighter
   (C) broader and fainter (D) broader and brighter

9. What is the cause of diffraction?

(A) Interference of primary wavelets
(B) Interference of secondary wavelets
(C) Reflection of primary wavelets
(D) Reflection of secondary wavelets

10. Which of the following phenomenon confirms the transverse nature of light waves.

(A) Polarization of light
(B) Diffraction of light
(C) Dispersion of light
(D) Refraction of light

11. Statement i: Wavefronts obtained from light emitted by a point source in an isotropic medium are always spherical

Statement ii: Speed of light in isotropic medium is constant.

(A) Both the statements are true and statement ii is the correct explanation for statement i.
(B) Both the statements are true but statement ii is not correct explanation for statement i.
(C) Statement i) is true but ii) is false.
(D) Both statements i) and ii) are false.

12. Statement i: Interference is not observed if the two coherent slit are broad.

Statement ii: A broad source is equivalent to many narrow slit sources.

(A) Both the statements are true and statement ii is the correct explanation for statement i.
(B) Both the statements are true but statement ii is not correct explanation for statement i.
(C) Statement i) is true but ii) is false.
(D) Both statements i) and ii) are false.

13. Statement i: When a thin transparent sheet is placed in front of both the slits of Young's experiment, the fringe width will remains same.

Statement ii: In Young's experiment, the fringe width is directly proportional to wavelength of the source

(A) Both statement i) and ii) are true and ii) is the correct explanation of assertion.
(B) Both statements are true but ii) is not the correct explanation of assertion.
(C) Statement i) is true but ii) is false.
(D) Both statements i) and ii) are false.

FILL IN THE BLANKS:

(*diffraction, decreases, spherical, interference, increases, polarisation*)

1. A wavefront coming from a point source of light is a __________ wavefront.
2. In Young's double slit experiment if the blue light is replaced by a red light, then the fringe width will be _______________.
3. The modification in the distribution of light intensity due to superposition of two or more light wave is called ______________of light.
4. The colours on a compact disc is due to _____________ light.
5. If the light from an ordinary sodium lamp is passes through a polaroid sheet. Then the intensity of emergent light will ______________.

TWO MARK QUESTIONS:

1. What is a wavefront? Name the wavefront emitted by a point source.
2. Write the conditions for constructive interference in terms of phase difference.
3. Write the conditions for constructive interference in terms of path difference.
4. Write the conditions for destructive interference in terms of phase difference.
5. Write the conditions for destructive interference in terms of path difference.
6. Write the expression for fringe width of interference pattern in Young's double slit experiment and explain the terms.
7. State and explain Malus' law of polarization of light.

THREE MARK QUESTIONS:

1. Explain the Huygen's wavefront concept.

2. Derive Snell's law using Huygen's principle.

3. Using Huygen's principle, show that the angle of incidence is equal to the angle of reflection during plane wave front reflected by a plane surface.

4. What is interference of light? Write the conditions for constructive interference and destructive interference in terms of path difference.

5. Describe the intensity distribution in diffraction pattern at single slit.

6. Write any three differences between interference and diffraction of light.

7. A parallel beam of light of wavelength 500 nm falls on a narrow slit and the resulting diffraction patter is observed on a screen 1m away. It is observed that the first minimum is at a distance of 2.5 mm from the centre of the screen. Find the width of the slit. (**0.2 mm)**

8. Light of wavelength 5500 A^0 falls normally on a slit width 22.0 $\times 10^{-5}$ cm. Calculate the angular position of the first minimum on either side of the central maxima. **(14.48^0)**

9. Mention the any three applications of Polaroids

10. Two polaroids are kept parallel to one other such that their pass axes are making an 60^0 to each other. If an unpolarized light of intensity I falls on the first polaroid find the intensity of light coming out of the other.

FIVE MARK QUESTIONS:

1. Give the theory of interference and hence arrive the conditions of constructive and destructive interference pattern. OR Derive the expression for resultant amplitude when two coherent waves are superpose on each other. Write conditions of constructive and destructive interference pattern.

2. With a schematic diagram, explain the Young's double slit experiment.

3. A beam of light consisting of two wavelengths of 4200 A^0 and 5600 A^0 is used to obtain interference fringes in Young's double slits experiment. Distance between the slits is 0.3 mm and distance between slits and screen is 1.5 m. Compute the least distance of the point from the central maximum where the bright fringes due to both the wavelengths coincide. **(8.4 mm)**

4. In Young's double slit experiment, distance between the slits is 0.5mm. When the screen is kept at a distance of 100cm from the slits, the distance of 9th bright fringe from the central fringe is 8.835mm. Find the wavelength of light used. **(4908 A^0)**

5. In Young's double slit experiment, the slits are separated by 0.3mm and the screen is placed at a distance of 1m from the slits. The distance between the first dark fringe and fourth bright fringe is found to be 0.6cm. Calculate the wavelength of the light used. **(5143 A^0)**

6. In Young's double slit experiment, distance between the slits is 0.3 mm. The screen is kept at a distance of 1.2 from the slits. If the wavelength of light used is 600 nm, find the position of 5th bright fringe and 3rd dark fringe. **(x_5 = 1.2 cm, x_3 = 0.6 cm)**

ANSWER KEYS TO MULTIPLE CHOICE QUESTIONS:

1	2	3	4	5	6	7	8	9	10	11	12	11	12	13
B	C	D	D	D	C	D	B	B	A	A	A	B	C	A

ANSWERS TO FIBS:

1. *spherical; 2. increase; 3. interference; 4.diffraction; 5. Decrease*

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11. DUAL NATURE OF RADIATION AND MATTER

MULTIPLE CHOICE QUESTIONS:

1. **Cathode ray particles are same as**
   (A) Protons (B) Electrons (C) α – particles (D) Neutrons
2. **In discharge tube, the cathode ray particles will travel with the speed of**
   (A) $3 \times 10^8 ms^{-1}$ (B) $6 \times 10^7 ms^{-1}$ (C) $2 \times 10^8 ms^{-1}$ (D) $2 \times 10^7 ms^{-1}$
3. **The sufficient energy by the electron to overcome the attractive pull of metal surface is called**
   (A)Work function (B) Photoelectric effect (C) Stopping Potential(D) Field emission
4. **Some alkali metals emit electrons when they are just illuminated by**
   (A) UV rays (B) visible light (C) X-rays (D) Gamma rays
5. **Some metals emit electrons when they are just illuminated by**
   (A) Infrared rays (B) Microwaves (C) UV rays (D) visible light
6. **The graph of photoelectric current versus intensity of incident radiation (for $\upsilon > \upsilon 0$)**
   (A) A straight line with y-intercept (B) A straight line with x-intercept
   (C) A straight line passing through origin (D) A non-linear curve
7. **In photoelectric effect, the time lag of electron emission is**
   (A)10^{-9}s (B) 10^{-5}s (C) 10^{-8} s (D) 10^5s
8. **The de Broglie wavelength of a moving particle is independent of _____________ of the particle.**
   (A) Charge (B) Mass (C) Speed (D) momentum
9. **Emission of electrons from a metal surface by heating is called**
   (A) Photoelectric emission (B) Thermionic emission
   (C) Field emission (D) Secondary emission
10. **In photoelectric effect experiment if only the frequency of incident radiation is increased, then**
    (A) The maximum kinetic energy of photoelectrons decreases.
    (B) The stopping potential increases
    (C) The photoelectric current increases
    (D) The photoelectric current decreases
11. **Which experiment proved that the charge is quantized?**
    (A) Oil drop experiment (B) Davisson and Germer experiment
    (C) α-ray scattering experiment (D) Franck – Hertz experiment
12. **The particle behavior of light was confirmed by following experiments**
    i) A H Compton, on scattering of X-rays from electrons
    ii) A Einstein, for photoelectric effect
    iii) Millikan, for charge of electrons
    iv) J.J Thomson's, on discharge tube experiment
    Choose the correct option
    (A) (i), (ii) & (iii) (B) (i), (ii) & (iv) (C) (ii), (iii) & (iv) (D) all of the above
13. **Photon energy is independent of**
    (A) Intensity of radiation (B) frequency of radiation
    (C) wavelength of radiation (D) none of these
14. **In a photon-particle collision, which of the following is conserved**
    (A) Only total energy is conserved (B) Only total momentum is conserved
    (C) Both total momentum and total energy are conserved
    (D) Neither total momentum nor total energy is conserved

15. **The gathering and focusing mechanism of light by the eye lens is described by**
(A) Wave nature of light (B) Particle nature of light
(C) Both A & B (D) neither A nor B

16. **Macroscopic particles in our daily life do not show wave-like properties, because**
(A) They are not associated with waves (B) Their wavelength is extremely high
(C) Their wavelength is zero (D) Their wavelength is negligibly small

17. **The absorption of light energy by retina of eye is described by**
(A) Wave nature of light (B) Particle nature of light
(C) Both A & B (D) neither A nor B

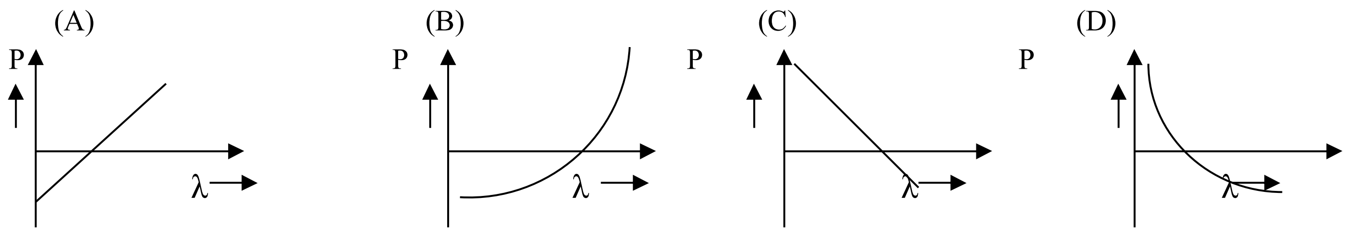
18. **The value of e/m was found to be**
i) Dependent on nature of metal.
ii) Independent of the nature of metal
iii) Dependent on the gas in discharge tube
iv) Independent on the gas in discharge tube.
Choose the correct option
(A) (i) and (iv) (B) (ii) and (iv) (C) (i) and (iii) (D) (ii) and (iii)

19. **The following statements relating wave theory to explain photoelectric emission are**
Statement – I: The maximum kinetic energy of photoelectron is directly proportional to intensity of light.
Statement – II: The frequency of radiation does not depend on photoelectric emission.
(A) Both I and II are true and II is the correct explanation of I
(B) Both I and II are true but II is not the correct explanation of I.
(C) I is true but II is false
(D) Both I and II are false

20. **The slope of stopping potential (V_0) versus frequency (υ) in Einstein's Photoelectric equation is**
(A) ϕ_0/ h (B) h/e (C) ϕ_0/h (D) h/e^2

21. **In a photoelectric experiment, the wavelength of incident radiation is reduced from 6000Å to 5000Å then**
(A) the frequency will decrease
(B) Stopping potential will increase
(C) Kinetic energy of emitted electrons will decrease
(D) the value of work function will increase

22. **Which of the following figures represents the variation of particle momentum with associated De Broglie wavelength?**



FILL IN THE BLANKS:

(***kinetic energy, Heinrich Hertz, intensity, wave, particle, photon***)

1. The phenomenon of photoelectric emission was discovered by ______________
2. Stopping potential is the measure of _________________ of liberated electrons
3. The Maxwell's equations of electromagnetism established the __________ nature of light.

4. In interaction with matter, light behaves as if it is made up of packet of energy called ___________ .
5. During photoelectric emission, the number of photoelectron emitted is directly proportional to ________________of incident light.

TWO MARK QUESTIONS:

1. On what factors the work function of the metal depend?
2. Define electron volt. Write its value.
3. Mention the different types of electron emission
4. Write Einstein's equation of photoelectric effect and explain the terms
5. Explain the Hertz observation on photoelectric effect.
6. Show graphically how the photocurrent varies with stopping potential for different frequencies but same intensity of incident radiation.
7. Show the variation of stopping potential with frequency of the incident radiation graphically
8. Find the maximum frequency of X-rays produced by 30 kV electrons. **[$\upsilon_{max} = 7.2 \times 10^{18}$ Hz]**
9. Calculate the stopping potential of electrons emitted from cesium metal if maximum kinetic energy is 0.346 eV. **[$V_0 = 0.346$V]**
10. The photoelectric cut off voltage in a certain experiment is 1.5 V. What is the maximum kinetic energy of photoelectrons emitted? **[$K_{max} = 2.4 \times 10^{-19}$ J]**
11. Calculate the de Broglie wavelength associated with an electron moving with a speed of 2×10^5 ms^{-1}. Given h = 6.625×10^{-34} Js and mass of electron m = 9.1×10^{-31}kg **[$\lambda = 3.636$ nm]**

THREE MARKS QUESTIONS:

1. Explain briefly the Hallwach's experimental observation on photoelectric effect.
2. Write the experimental observation of photoelectric effect.
3. Write any three properties of photon.
4. Explain briefly the Lenard's experimental observations on photoelectric effect.
5. An alpha particle, a proton and an electron are moving with equal kinetic energy. Which one of these particles has the longest de-Broglie wavelength? Give reason.
6. The work function of certain metal is 4.2 eV. Will this metal give photoelectric emission for incident radiation of wavelength 330 nm? **[$\lambda_0 = 295$ nm, $\lambda > \lambda_0$ no photoemission]**

FIVE MARK QUESTIONS:

1. a) Who proposed the dual nature of matter? (1)
   b) What are matter waves? (1)
   c) Define the terms: i) Photoelectric saturation current ii) Threshold frequency
   iii) Stopping potential (3)
2. a) Mention the equation for de-Broglie's wavelength of matter waves of a moving particle and explain the terms. (2)
   b) Using Einstein's photoelectric equation, explain the experimental results of photoelectric effect. (3)
3. a) With a neat diagram, describe an experiment to study the photoelectric effect. (3)
   b) How does photocurrent and stopping potential depends on intensity of incident radiation in photoelectric effect. (2)
4. The work function of caesium metal is 2.14 eV. when light of frequency 6×10^{14} Hz is incident on the metal surface, photoemission of electrons occurs. Find a) Energy of incident photon b)Maximum kinetic energy of photoelectrons. **[E = 2.486eV, $(K.E)_{max} = 0.346$ eV]**
5. Light of frequency 2.4×10^{14} Hz is incident on a metal surface. Electrons with their maximum speed of 7.5×10^5 ms^{-1} are ejected from the surface. Calculate the threshold frequency of the metal surface for

the photoemission of electrons and work function of the metal surface. Given: Planck's constant $h = 6.625 \times 10^{-34}$ Js and mass of electron m = 9.1×10^{-31} kg. **[$\upsilon_0 = 4.55 \times 10^{14}$ Hz, ϕ_o = 1.88 Ev or 3.01×10^{-19} J]**

6. A monochromatic source of light of power 36 W emits photons of wavelength 589 nm. Calculate (a) Energy of photon emitted by the source (b) Number of photons emitted by the source in one second
[E = 3.37×10^{-19} J, N = 10.67×10^{19} photons/s]

7. Light of frequency 7.21×10^{14} Hz is incident on a metal surface. The cut-off wavelength for photoelectric emission from the metal surface is 540 nm. Calculate the speed of the photoelectrons emitted from the surface. Given: Planck's constant $h = 6.625 \times 10^{-34}$ Js and mass of electron m = 9.1×10^{-31} kg.
[v = 4.91×10^{5} ms^{-1}]

8. When light of wavelength 400 nm is incident on a photosensitive surface, the stopping potential for the photoelectrons emitted is found to be 0.96 V. When light of wavelength 500 nm is incident on the same photosensitive surface, the stopping potential is found to be 0.34 V. Calculate the Planck's constant. Given: speed of light in vacuum is 3×10^{8} ms^{-1} and electronic charge e = 1.6×10^{-19} C.
[h = 6.625×10^{-34} Js]

ANSWER KEYS TO MULTIPLE CHOICE QUESTIONS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
B	B	A	B	C	C	A	A	B	C	A	C	A	C	A	D	B	B	A	B	B	D

ANSWERS TO FIBS:

1. Heinrich Hertz, 2. kinetic energy, 3. wave, 4. photon, 5. Intensity

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12. ATOMS

MULTIPLE CHOICE QUESTIONS:

1. **The condensed matter and dense gases at all temperature emit electromagnetic radiation due to**
(A) High temperature (B) Oscillations of atoms and molecules
(C) Head on collision between atoms and molecules (D) None of these

2. **The source of α-particle in Geiger-Marsden experiment is**
(A) radium-226 (B) bismuth - 214 (C) radon - 222 (D) cobalt - 60

3. **The thickness of gold foil in α-particle scattering experiment**
(A) 1.1 mm (B) 1.2×10^{-4}mm (C) 2.1×10^{-4}mm (D) 2.1 cm

4. **The detector in α-particle scattering experiment is coated with**
(A) silver nitrate screen (B) phosphorescent (C) barium sulphide (D)zinc sulphide

5. **The light emitted by mercury vapour lamp is due to**
Statement I: Interaction between the individual atoms
Statement II: The average spacing between the atoms is large
(A) Both I and II are true and II is correct explanation of I
(B) Both I and II are true but II is not correct explanation of I
(C) I is true but II is false
(D) Both I and II are false.

6. **From kinetic theory, the size of an atom was known to be**
(A) 10^{-10} m (B) 10^{-14} m (C) 10^{-18} m (D) 10^{-22} m

7. The size of atom is about ___________ times larger than the size of the nucleus

(A) 10^2 to 10^3 (B) 10^3 to 10^4 (C) 10^4 to 10^5 (D) 10^5 to 10^6

8. The α-particles are nuclei of

(A) H-atom (B) H^+ - atom (C) He – atom (D) He^{2+} - atom

9. Rutherford α-particles scattering experiment determines the size of

(A) Nucleus (B) Electron (C) Proton (D) Neutron

10. The negative sign in Electrostatic Potential energy of an electron signifies that

(A) Potential energy of an electron is unstable (B) Electrostatic force is in the – r direction.

(C) Kinetic energy of all electron is constant (D) None of these.

11. The emission line spectrum is a characteristics of

(A) a molecule (B) a solid (C) an atom (D) a liquid

12. The emission line spectrum serves as

(A) Paper print of gases (B) Photo print of gases

(C) Colour print of gases (D) Finger print of gases

13. Bohr's atomic model imitates

(A) sun-earth system (B) earth-moon system (C) sun-planet system (D) sun-comet system

14. The principal quantum number for Bohr Radius is

(A) $n^2 = 4$ (B) $n^2 = 9$ (C) $n^2 = 1$ (D) $n^2 = 16$

15. The minimum energy required to free the electron from the ground state of the hydrogen atom is called

(A) first excitation energy (B) zero potential energy

(C) excitation energy (D) ionisation energy

16. According to Louis De Broglie, waves associated with orbital electrons are

(A) Progressive wave (B) Stationary wave (C) Longitudinal wave (D) Continuous wave

17. Bohr model is applicable to

(A) H atom (B) He^+ atom (C) Li^{++} atom (D) All of these

18. For an electron revolving around the nucleus,

(A) kinetic energy and potential energy are positive, total energy is negative

(B) kinetic energy is positive, potential energy and total energy are negative

(C) potential energy is negative, kinetic energy and total energy are positive

(D) kinetic energy and potential energy are negative, total energy is positive.

19. Statement I: The atom is electrically neutral.

Statement II: An atom contains some positive charge to neutralize few negative charge of the electrons

(A) Both I and II are true and II is correct explanation of I

(B) Both I and II are true but II is not correct explanation of I

(C) I is true but II is false

(D) Both I and II are false.

20. Statement I: Many of α-particles pass through the gold foil in α-particle scattering experiment

Statement II: Only about 14% of the incident α-particles scatter by more than 1^0.

(A) Both I and II are true and II is correct explanation of I

(B) Both I and II are true but II is not correct explanation of I

(C) I is true but II is false

(D) Both I and II are false.

21. When an electron in Hydrogen atom revolves in stationary orbit, it

(A) does not radiate energy though its velocity changes

(B) does not radiate energy and velocity remains unchanged

(C) radiates energy but its velocity is unchanged

(D) radiates energy with the change of velocity

22. Radius of first orbit of hydrogen atom is 0.53Å. The radius of its fourth orbit will be

(A) 0.193Å (B) 4.25Å (C) 2.12Å (D) 8.48Å

23. When a hydrogen atom is raised from the ground state to an excited state

(A) potential energy increases and kinetic energy decreases
(B) potential energy decreases and kinetic energy increases
(C) Both kinetic energy and potential energy increases
(D) Both kinetic energy and potential energy decreases

24. According to classical theory,
Statement I: The electron will fall into the nucleus
Statement II: An accelerated electron emits radiation in circular path

(A) Both I and II are true and II is correct explanation of I
(B) Both I and II are true but II is not correct explanation of I
(C) I is true but II is false
(D) Both I and II are false.

FILL IN THE BLANKS:

(*Nucleus, -13.6eV, +13.6eV, Different, Dark, Bright*)

1. The entire mass of an atom is concentrated in a small volume called ________________.
2. Energy of the electron in the first orbit of hydrogen atom is ______________.
3. Ionization energy of the hydrogen atom is ___________________
4. Line emission spectrum consist of bright line on a ______________background.
5. Line absorption spectrum consist of dark line on a _____________ background.

TWO MARK QUESTIONS:

1. Write the two limitations of Bohr's atom model.
2. Mention the different types of atomic model.
3. What is ionization energy of an electron? Give its value for ground state of H atom.
4. What is the energy for highest energy state in H atom? How does energy states arranged as principal quantum number increases.
5. What does the negative sign in total energy of the electron signifies? What happens if total energy is positive?
6. What is Bohr radius? Write its formula.
7. Mention the expression for energy of the n^{th} stationary orbit of hydrogen atom. Explain its terms.
8. Draw the trajectories traced by different alpha particles in Geiger – Marsden experiment .
9. Calculate the energy required to excite an electron from ground state to second excited state. **[12.09 eV]**

THREE MARK QUESTIONS:

1. Write the three postulates of Bohr's atom model
2. Give De-Broglie's explanation of Bohr's second postulate of quantization of angular momentum
3. Draw the neat diagram representing the Schematic arrangement of Geiger-Marsden setup for the alpha particle scattering.
4. Define impact parameter. What are the angle of scattering for a) minimum impact parameter; b) larger impact parameter
5. Explain J J Thomson's plum pudding model on atomic structure.
6. Draw neat labeled diagram for energy level of H atom.

FIVE MARK QUESTIONS:

1. Derive an expression for energy of an electron in nth stationary orbit of hydrogen atom by assuming the expression for radius.
2. A Hydrogen atom initially in the ground level absorbs a photon, which excites it to the n = 4 level. Determine the wavelength and frequency of photon. **[$\lambda = 9.75 \times 10^{-8}$ m, $\upsilon = 3.08 \times 10^{15}$ Hz]**
3. Using the Bohr's model calculate the speed of the electron in the hydrogen atom in n = 1, 2 levels and also calculate the orbital period in each of these levels.
[$v_1 = 2.18 \times 10^6$ ms^{-1}, $T_1 = 1.528 \times 10^{-16}$ s, $v_2 = 1.09 \times 10^6$ ms^{-1}, $T_2 = 12.22 \times 10^{-16}$ s]
4. It is found experimentally that 13.6eV energy is required to separate a hydrogen atom into a proton and an electron. Compute the orbital radius and the velocity of the electron in a hydrogen atom.
[**$r = 5.3 \times 10^{-11}$ m, $v = 2.2 \times 10^6$ ms^{-1}**]
5. In a Geiger Marsden experiment, what is the distance of closest approach to the nucleus of a 7.7 MeV, α-particle before it comes momentarily to rest and reverses its direction? **[d = 30 fm]**
6. The electron in a given Bohr orbit has a total energy of – 1.5 eV. Calculate its a) kinetic energy b) potential energy c) wavelength of emitted light, when the electron makes a transition to the ground state. Given: Ground state energy = – 13.6 eV. **[K = 1.5 eV, U = – 3eV, λ = 1022.7 Å]**

ANSWER KEYS TO MULTIPLE CHOICE QUESTIONS:

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
B	**B**	**C**	**D**	**A**	**A**	**C**	**D**	**A**	**B**	**C**	**D**
13	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
C	**C**	**D**	**B**	**D**	**B**	**B**	**C**	**A**	**D**	**A**	**A**

ANSWERS TO FIBS:

1.nucleus 2. -13.6eV, 3. +13.6eV 4. dark 5. bright

****

13. NUCLEI

MULTIPLE CHOICE QUESTIONS:

1. Nucleus of an atom whose atomic mass is 24 consists of

(A) 11 electrons, 11 protons and 13 neutrons (B) 11 electrons, 13 protons and 11 neutrons
(C) 11 protons and 13 neutrons (D) 11 protons and 13 electrons

2. Isotopes are atoms having

(A) Same number of protons but different number of neutrons
(B) Same number of neutrons but different number of protons
(C) Same number of protons and neutrons
(D) None of the above

3. The radius of a nucleus of a mass number *A* is directly proportional to

(A) A^3 (B) A (C) $A^{2/3}$ (D) $A^{1/3}$

4. Which of the following is correct for nuclear forces

(A) Short ranged attractive and charge independent
(B) Short ranged attractive and charge dependent
(C) Long ranged repulsive and charge independent
(D) Long ranged repulsive and charge dependent

5. Density of any nucleus is

(A) 2.29×10^{10} kgm^{-3} (B) 2.29×10^{17} kgm^{-3} (C) 2.29×10^{12} kgm^{-3} (D) 2.29×10^{13} kgm^{-3}

6. Binding energy of a nucleus is

(A) Energy given to its nucleus during its formation

(B) Total mass of nucleus converted to energy units

(C) Energy required to break a nucleus into constituent nucleons

(D) Total K.E. and P.E. of the nucleons in the nucleus

7. The binding energy per nucleon is maximum in the case of

(A) ${}^{4}_{2}He$ (B) ${}^{56}_{26}Fe$ (C) ${}^{141}_{56}Ba$ (D) ${}^{235}_{92}U$

8. For effective nuclear forces, the distance should be

(A) 10^{-10} m (B) 10^{-13} m (C) 10^{-15} m (D) 10^{-10} m

9. The α-particle is the nucleus of an atom of

(A) Neon (B) Hydrogen (C) Helium (D) Deuterium

10. Radioactivity is

(A) Reversible process (B) Self disintegration process

(C) Spontaneous process (D) Both (B) and (C)

11. Radioactive substance emits

(A) α-rays (B) β- rays (C) γ-rays (D) All of the above

12. Fusion reaction takes place at high temperature because

(A) Atoms are ionised at high temperature

(B) Molecules break-up at high temperature

(C) Nuclei break-up at high temperature

(D) Kinetic energy is high enough to overcome repulsion between nuclei

13. The explosion of the atomic bomb takes place due to

(A) Nuclear fission (B) Nuclear fusion (C) Scattering (D) Thermionic emission

14. Energy generation in stars is mainly due to

(A) Photo emission (B) Fission of heavy nuclei

(C) Fusion of light nuclei (D) Fusion of heavy nuclei

15. Fusion reaction is initiated with the help of

(A) Low temperature (B) High temperature (C) Neutrons (D) Any particle

16. In ${}^{226}_{88}Ra$ nucleus, there are

(A) 138 protons and 88 neutrons (B) 138 neutrons and 88 protons

(C) 226 protons and 88 electrons (D) 226 neutrons and 138 electrons

17. The mass and energy equivalent to 1 *a.m.u.* respectively

(A) 1.67×10^{-27} g, 9.315 MeV (B) 1.67×10^{-31} g, 1 MeV

(C) 1.67×10^{-27} g, 1 MeV (D) 1.67×10^{-27} kg, 931.5 MeV

18. M_n and M_p represent mass of neutron and proton respectively. If an element having atomic mass *M* has *N*-neutron and *Z*-proton, then the correct relation will be

(A) $M < [NM_n + ZM_P]$ (B) $M > [NM_n + ZM_P]$

(C) $M = [NM_n + ZM_P]$ (D) $M = N[M_n + M_P]$

19. Two nucleons are at a separation of 1×10^{-15} m. The net force between them is F_1, if both are neutrons, F_2 if both are protons and F_3 if one is a proton and other is a neutron. In such a cas

(A) $F_2 > F_1 > F_3$ (B) $F_2 > F_1 = F_3$ (C) $F_1 = F_2 = F_3$ (D) $F_2 < F_1 < F_3$

20. **Which of the following is the fusion reaction**

(A) ${}_1H^2 +_1 H^2 \rightarrow_2 He^4$ (B) ${}_0n^1 +_7 N^{14} \rightarrow_6 C^{14} +_1 H^1$

(C) ${}_0n^1 +_{92} U^{238} \rightarrow_{93} Np^{239} + \beta^{-1} + \gamma$ (D) ${}_1H^3 \rightarrow_2 He^3 + \beta^{-1} + \gamma$

FILL IN THE BLANKS:

(***nuclear fission, independent, 26.7 MeV, atomic mass unit, mass spectrometer, nuclear fusion***)

1. ________________ is $\left(\frac{1}{12}\right)^{th}$ of mass of the carbon-12 atom in stable state.
2. The instrument is used to measure the atomic masses is _____________.
3. The nuclear density is ____________ of its mass number.
4. The source of energy in nuclear reactors, which produce electricity is _____________.
5. Four hydrogen atoms combine to form an ${}_{2}^{4}He$ atom with a release of ___________ of energy.

TWO MARK QUESTIONS:

1. What are isotopes? Give an example.
2. What are isobars? Give an example.
3. What are isotones? Give an example.
4. Write the expression for mass defect. Explain the terms.
5. What is nuclear binding energy? Explain.
6. What is meant by binding energy per nucleon? Explain.
7. Nuclear forces are strongest forces in nature. Why?
8. What are controlled and uncontrolled chain reactions?
9. What is a controlled thermonuclear fusion? Explain.
10. What is the radius of a nucleus of mass number 27? Given R_0=1.2 fm. **[3.6 fm]**

THREE MARK QUESTIONS:

1. Write the names and formula of isotopes of hydrogen.
2. Show that 1 atomic mass unit (u) = 1.66×10^{-27} kg
3. How the size of the nucleus is experimentally determined? Explain.
4. Explain Einstein's mass-energy relation.
5. Draw a graph showing the variation of potential energy as a function of their separation. What is the significance of negative potential energy in this graph?
6. What is nuclear fission? Explain with example.
7. What is nuclear fusion? Explain with example.
8. Two nuclei have mass numbers in the ratio 8 : 125. What is the ratio of their nuclear radii? **[2 : 5]**
9. Calculate the mass defect of oxygen nucleus (${}_{8}^{16}O$)using the following data in Mev: Mass of proton = 1.007825 u; Mass of neutron =1.008665 u; Mass of oxygen nucleus = 15.995, u **[0.13692 u]**
10. Mass defect of chlorine (${}_{17}^{35}Cl$) nucleus is 0.31092 u. Calculate binding energy and binding energy per nucleon of an chlorine nucleus. **[289.466 MeV, 8.2704 MeV]**

FIVE MARK QUESTIONS:

1. Explain the features of binding energy curve.
2. Distinguish between nuclear fission and nuclear fusion.
3. What is a nuclear force? Write any four characteristics of nuclear force.

4. Calculate the binding energy per nucleon of the nucleus $^{209}_{83}Bi$, given that nuclear mass of Bi is 208.980388u, mass of proton = 1.007825u, mass of neutron = 1.008665u. **[7.641 MeV]**

5. Calculate energy released in joule when 2 gram of U^{235} undergoes fission completely as per the following equation. $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3^{1}_{0}n$ + energy.

6. Given: rest mass of U^{235} = 235.044 u; rest mass of Ba^{141} = 140.920 u; rest mass of Kr^{92} = 91.885 u; rest mass of $^{1}_{0}n$ = 1.009 u. **[1.688×10^{11} J]**

7. How long can an electric lamp of 100 W be kept glowing by fusion of 2.0 kg deuterium? The fusion reaction can be taken as $^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{2}He + ^{1}_{0}n$ + 3.27 MeV **[4.99×10^{4} years]**

ANSWER KEYS TO MULTIPLE CHOICE QUESTIONS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
C	A	D	A	B	C	B	C	C	D	D	D	A	C	B	B	D	A	C	A

ANSWERS TO FIBS:

1. atomic mass unit 2. mass spectrometer 3. independent 4. nuclear fission 5. 26.7 MeV.

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14. SEMICONDUCTOR ELECTRONICS

MULTIPLE CHOICE QUESTIONS:

1. **Following pairs of elemental semiconductors**
   (A) Silicon and aluminium (B) silicon and germanium
   (C) germanium and cadmium (D) aluminium and cadmium
2. **The energy band determines the electrical conductivity of the material is**
   (A) Conduction band (B) energy gap
   (C) valence band (D) all the above
3. **In an intrinsic semiconductor, number of free electros is**
   (A) Greater than number of holes (B) lesser than number of holes
   (C) equal to number of holes (D) more than number of atoms.
4. **The electrical conductivity of pure germanium can be increased by**
   (A) increasing the temperature (B) doping with acceptor impurities
   (C) doping with donor impurities (D) all the above
5. **When the electrical conductivity of a semiconductor is due to the breaking of its covalent bonds, then the semiconductor is said to be**
   (A) Donor (B) Acceptor (C) Intrinsic (D) Extrinsic
6. **The valence of an impurity added to germanium crystal in order to convert it into a *P*-type semiconductor is**
   (A) 6 (B) 5 (C) 4 (D) 3
7. **The majority charge carriers in *P*-type semiconductor are**
   (A) Electrons (B) Protons (C) Holes (D) Neutrons

8. **A semiconductor dopped with a donor impurity is**

(A) p-type (B) *n*-type (C) *npn* type (D) *pnp* type

9. **A *P*-type semiconductor can be obtained by adding**

(A) Arsenic to pure silicon (B) Gallium to pure silicon

(C) Antimony to pure germanium (D) Phosphorous to pure germanium

10. **The thickness of depletion layer is approximately**

(A) 1 μm (B) 1 mm (C) 1 cm (D) 1m

11. **The diffusion current in a p-n junction is greater than the drift current in magnitude**

(A) If the junction is forward-biased (B) If the junction is reverse-biased

(C) if the junction is unbiased (D) both (A) and (B)

12. **When a *PN* junction diode is reverse biased**

(A) Electrons and holes are attracted towards each other and move towards the depletion region

(B) Electrons and holes move away from the junction depletion region

(C) Height of the potential barrier decreases

(D) No change in the current takes place

13. **The cut-in voltage for silicon diode is approximately**

(A) 0.2 V (B) 0.7 V (C) 1.1 V (D) 1.4 V

14. **The *PN* junction diode is used as**

(A)An amplifier (B) A rectifier (C) An oscillator (D) A modulator

15. **The output of the full wave rectifier is**

(A) Pure AC (B) pure DC (C) pulsating DC (D) pulsating AC

16. **The forbidden energy band gap in conductors, semiconductors and insulators are Eg_1, Eg_2 and Eg_3 respectively. The relation among them is**

(A) $Eg_1 = Eg_2 = Eg_3$ (B) $Eg_1 < Eg_2 < Eg_3$

(C) $Eg_1 > Eg_2 > Eg_3$ (D) $Eg_1 < Eg_2 > Eg_3$

17. **The energy band gap in Germanium and silicon in *eV* respectively is**

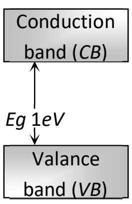
(A) 0.7, 1.1 (B) 1.1, 0.7 (C) 1.1, 0 (D) 0, 1.1

18. **In a semiconductor, the concentration of electrons is $8\times10^{14}/cm^3$ and that of the holes is $5\times10^{12}cm^3$. The semiconductor is**

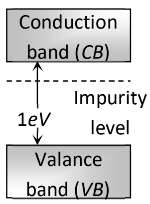
(A) p-type (B) *n*-type (C) Intrinsic (D) *pnp*-type

19. **Which of the following energy band diagram shows the *N*-type semiconductor**

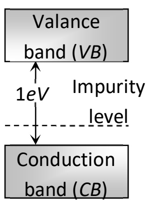
(A)



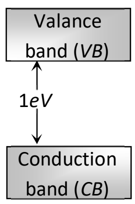
(B)



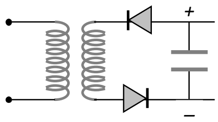
(C)

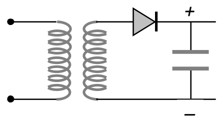


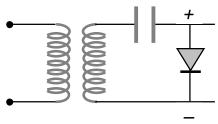
(D)

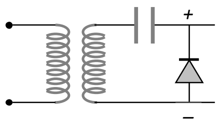


20. Which is the correct diagram of a half-wave rectifier

(A) 

(B) 

(C) 

(D) 

FILL IN THE BLANKS:

(***depletion region, electrons, saturation current, one, valence band, holes*** **)**

1. ______________is the lower band which is completely occupied by the 4N valence electron at temperature of absolute zero.

2. The ratio of number of holes to number of electrons in an intrinsic semiconductor is _________.

3. In n-type semiconductor, the number of __________ is more than the number of holes.

4. _____________ is the space charge region on either side of the junction where no mobile charge carriers are present.

5. In a reverse biased p-n junction, the current through the circuit is called reverse ______________.

TWO MARK QUESTIONS:

1. Write two advantages of semiconductor devices over vacuum tubes.
2. Explain the formation of energy bands in solid.
3. What is forbidden energy band? Explain
4. What is a semiconductor? Give an example.
5. Name the types of semiconductors.
6. What is an intrinsic semiconductor? Give an example.
7. Draw the energy band diagram of an intrinsic semiconductor.
8. What is meant by doping? What are dopants?
9. Name two types of extrinsic semiconductors.
10. Explain how a hole in a semiconductor is formed?
11. Why majority charge carriers increase on doping a pure semiconductor?
12. Draw the energy band diagram of p-type semiconductor.
13. Draw the energy band diagram of n-type semiconductor.
14. Mention two important processes occur during the formation of p-n junction.
15. Give the circuit symbol of a p-n junction diode. Mention the significance of arrow in it.
16. What happens to the width of depletion layer of a p-n junction diode when it is
(i) forward biased and (ii) reverse biased?
17. What is the resistance of an ideal diode when (i) forward biased and (ii) reverse biased?
18. Under what condition does a p-n junction diode work as (i) a closed switch and (ii) an open switch.

THREE MARK QUESTIONS:

1. What is the order of the resistivity in a (i) conductor (ii) semiconductor (iii) insulator.
2. Define valence band, conduction band and energy gap.

3. Classify conductors, semiconductors and insulators on the basis of energy gap.
4. What is the order of the energy gap in a (i) conductor (ii) semiconductor and (iii) insulator.
5. Distinguish between intrinsic and extrinsic semiconductor.
6. Explain how a p-type semiconductor obtained from an intrinsic semiconductor.
7. Explain how a n-type semiconductor obtained from an intrinsic semiconductor.
8. Distinguish between n-type and p-type type semiconductor.
9. Explain the working of p-n junction diode when it is in forward bias.
10. Explain the working of p-n junction diode when it is in reverse bias.
11. How is forward biasing different from reverse biasing in a p-n junction diode?
12. Define the terms (i) cut in voltage (ii) breakdown voltage and (iii) reverse saturation current.

FIVE MARK QUESTIONS:

1. Explain the construction and formation of a p-n junction.
2. Draw the I-V characteristics of p-n junction diode and hence discuss the resistance of the junction in both forward bias and reverse bias conditions.
3. What is rectifier? Describe with a circuit diagram, the working of a semiconductor diode as a half wave rectifier. Draw input and output waveforms.
4. What is rectification? Describe with a circuit diagram, the working of a semiconductor diode as a full wave rectifier. Draw input and output waveforms.

ANSWER KEYS TO MULTIPLE CHOICE QUESTIONS:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
B	A	C	D	C	D	C	B	B	A	A	B	B	B	C	B	A	B	B	B

ANSWERS TO FIBS:

1. valence band 2. one 3. electrons 4. depletion region 5.saturation current

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