12-PHYSICS

STUDENT SUPPORT MATERIAL

Competency Focused Questions in the form of MCQs/Case Based/Assertion-Reasoning type for the Academic Session 2023-24.

KENDRIYA VIDYALAYA SANGATHAN
HYDERABAD REGION

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2	Current Electricity	Mrs Minu Singh	AFS Hakimpet, Secunderabad
3	Magnetic Effects of current & Magnetism	Mr Murali Krishna	No.1, Srivijayanagar, Vishakhapatnam
4	Electromagnetic Induction & Alternating Currents	Mr Anand Bhushan	ONGC Rajahmundry
5	Electromagnetic Waves	Mrs Minu Singh	AFS Hakimpet, Secunderabad
6	Optics	Mr KTS Srivatsa	Waltair, Vishakhapatnam
7	Dual Nature of Radiation and Matter	Mrs Rachel Joshua	Trimulgherry
8	Atoms and Nuclei	Mrs Rachel Joshua	Trimulgherry
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INDEX

Unitwise Weightage

CLASS XII (2023-24)

PHYSICS (THEORY)

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

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

QUESTION PAPER DESIGN

Theory (Class: XI/XII)

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

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

12-Physics (Theory) Syllabus (CBSE) for the session 2023-24

Unit I: Electrostatics **26 Periods**

Chapter–1: Electric Charges and Fields

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

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

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

Chapter–2: Electrostatic Potential and Capacitance

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

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

Unit II: Current Electricity **18 Periods**

Chapter–3: Current Electricity

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

Unit III: Magnetic Effects of Current and Magnetism 25 Periods

Chapter–4: Moving Charges and Magnetism

Concept of magnetic field, Oersted's experiment.

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

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

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

Chapter–5: Magnetism and Matter

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

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

Unit IV: Electromagnetic Induction and Alternating Currents 24 Periods

Chapter–6: Electromagnetic Induction

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

Chapter–7: Alternating Current

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

AC generator, Transformer.

Unit V: Electromagnetic waves 04 Periods

Chapter–8: Electromagnetic Waves

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

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

Unit VI: Optics 30 Periods

Chapter–9: Ray Optics and Optical Instruments

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

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

Chapter–10: Wave Optics

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

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

Chapter–11: Dual Nature of Radiation and Matter

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

Experimental study of photoelectric effect

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

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

Chapter–12: Atoms

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

Chapter–13: Nuclei

Composition and size of nucleus, nuclear force

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

Unit IX: Electronic Devices **10 Periods**

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

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

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

12-PHYSICS PRACTICAL EXAMINATION EVALUATION SCHEME

Max. Marks: 30

Time 3 hours

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

CLASS : XII

SESSION: 2023-24

CBSE SAMPLE QUESTION PAPER

SUBJECT: PHYSICS (THEORY)

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

General Instructions:

(1) There are 33 questions in all. All questions are compulsory.
(2) This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
(3) All the sections are compulsory.
(4) **Section A** contains sixteen questions, twelve MCQ and four Assertion Reasoning based of 1 mark each, **Section B** contains five questions of two marks each, **Section C** contains seven questions of three marks each, **Section D** contains two case study based questions of four marks each and **Section E** contains three long answer questions of five marks each.
(5) There is no overall choice. However, an internal choice has been provided in one question in Section B, one question in Section C, one question in each CBQ in Section D and all three questions in Section E. You have to attempt only one of the choices in such questions.
(6) Use of calculators is not allowed.
(7) You may use the following values of physical constants where ever necessary
   i. $c = 3 \times 10^{8}$ m/s
   ii. $m_e = 9.1 \times 10^{-31}$ kg
   iii. $e = 1.6 \times 10^{-19}$ C
   iv. $\mu_0 = 4\pi \times 10^{-7}$ TmA^{-1}
   v. $h = 6.63 \times 10^{-34}$ Js
   vi. $\varepsilon_0 = 8.854 \times 10^{-12}$ $C^2N^{-1}m^{-2}$
   vii. Avogadro's number = 6.023×10^{23} per gram mole

SECTION-A

1. Which of the following is not the property of an equipotential surface?
(a) They do not cross each other.
(b) The work done in carrying a charge from one point to another on an equipotential surface is zero.
(c) For a uniform electric field, they are concentric spheres.
(d) They can be imaginary spheres.

2. An electric dipole placed in an electric field of intensity 2×10^5 N/C at an angle of 30° experiences a torque equal to 4 Nm. The charge on the dipole of dipole length 2 cm is
(a) 7 µC (b) 8 mC (c) 2 mC (d) 5 mC

3. A metallic plate exposed to white light emits electrons. For which of the following colours of light, the stopping potential will be maximum?
(a) Blue (b) Yellow (c) Red (d) Violet

4. When alpha particles are sent through a thin gold foil, most of them go straight through the foil, because
(a) alpha particles are positively charged
(b) the mass of an alpha particle is more than the mass of an electron
(c) most of the part of an atom is empty space
(d) alpha particles move with high velocity

5. An electron is moving along positive x-axis in a magnetic field which is parallel to the positive y-axis. In what direction will the magnetic force be acting on the electron?
(a) Along -x axis (b) Along -z axis
(c) Along +z axis (d) Along -y axis

6. The relative permeability of a substance X is slightly less than unity and that of substance Y is slightly more than unity, then
(a) X is paramagnetic and Y is ferromagnetic
(b) X is diamagnetic and Y is ferromagnetic
(c) X and Y both are paramagnetic
(d) X is diamagnetic and Y is paramagnetic

7. An ammeter of resistance 0.81 ohm reads up to 1 A. The value of the required shunt to increase the range to 10 A is
(a) 0.9 ohm (b) 0.09 ohm (c) 0.03 ohm (d) 0.3 ohm

8. An electron with angular momentum L moving around the nucleus has a magnetic moment given by

(a) e L/ 2m (b) e L/3m (c) e L /4m (d) e L / m

9. The large scale transmission of electrical energy over long distances is done with the use of transformers. The voltage output of the generator is stepped-up because of

(a) reduction of current (b) reduction of current and voltage both

(c) power loss is cut down (d) a and c both

10. The diagram below shows the electric field (**E**) and magnetic field (**B)** components of an electromagnetic wave at a certain time and location.

The direction of the propagation of the electromagnetic wave is

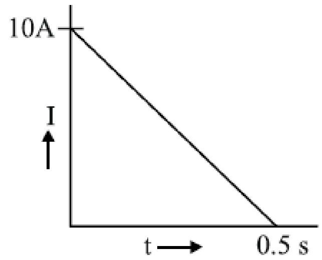
(a) perpendicular to **E** and **B** and out of plane of the paper

(b) perpendicular to **E** and **B** and into the plane of the paper

(c) parallel and in the same direction as **E**

(d) parallel and in the same direction as **B**

11. In a coil of resistance 100 Ω a current is induced by changing the magnetic flux through it. The variation of current with time is as shown in the figure. The magnitude of change in flux through coil is



(a) 200 Wb (b) 275 Wb (c) 225 Wb (d) 250 Wb

12. The energy of an electron in n[th] orbit of hydrogen atom is E_n= - $13.6/n^2 eV$.The negative sign of energy indicates that

(a) electron is free to move.

(b) electron is bound to the nucleus.

(c) kinetic energy of electron is equal to potential energy of electron.

(d) atom is radiating energy.

For Questions 13 to 16, two statements are given –one labelled Assertion (A) and other labelled Reason (R). Select the correct answer to these questions from the options as given below.

a) **If both Assertion and Reason are true and Reason is correct explanation of Assertion.**

b) **If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.**

c) **If Assertion is true but Reason is false.**

d) **If both Assertion and Reason are false.**

13. **Assertion** (A): For the radiation of a frequency greater than the threshold frequency, photoelectric current is proportional to the intensity of the radiation.
Reason (R) : Greater the number of energy quanta available, greater is the number of electrons absorbing the energy quanta and greater is number of electrons coming out of the metal.

14. **Assertion (A)** : Putting p type semiconductor slab directly in physical contact with n type semiconductor slab cannot form the pn junction.
Reason (R) : The roughness at contact will be much more than inter atomic crystal spacing and continuous flow of charge carriers is not possible.

15. **Assertion (A) :** An electron has a higher potential energy when it is at a location associated with a negative value of potential and has a lower potential energy when at a location associated with a positive potential.
Reason (R) : Electrons move from a region of higher potential to a region of lower potential.

16. **Assertion (A) :** Propagation of light through an optical fibre is due to total internal reflection taking place at the core-cladding interface.
Reason (R): Refractive index of the material of the cladding of the optical fibre is greater than that of the core.

SECTION-B

17. (a) Name the device which utilizes unilateral action of a pn diode to convert ac into dc.
(b) Draw the circuit diagram of full wave rectifier.

18. The wavelength λ of a photon and the de Broglie wavelength of an electron of mass m have the same value. Show that the energy of the photon is 2λmc/h times the kinetic energy of the electron, where c and h have their usual meanings.

19. A ray of monochromatic light passes through an equilateral glass prism in such a way that the angle of incidence is equal to the angle of emergence and each of these angles is 3/4 times the angle of the prism. Determine the angle of deviation and the refractive index of the glass prism.

20. A heating element using nichrome connected to a 230 V supply draws an initial current of 3.2 A which settles after a few seconds to a steady value of 2.8 A. What is the steady temperature of the heating element if the room temperature is 27.0 °C and the temperature coefficient of resistance of nichrome is 1.70×10^{-4} $°C^{-1}$?

21. Show that the least possible distance between an object and its real image in a convex lens is 4f, where f is the focal length of the lens.

OR

In an astronomical telescope in normal adjustment a straight black line of length L is drawn on the objective lens. The eyepiece forms a real image of this line whose length is l. What is the angular magnification of the telescope?

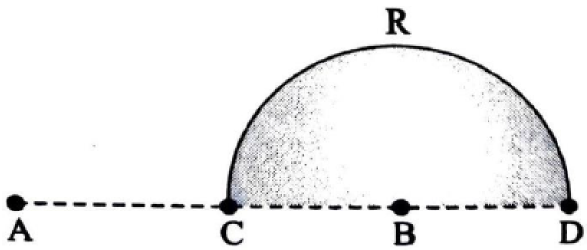
SECTION-C

22. A given coin has a mass of 3.0 g. Calculate the nuclear energy that would be required to separate all the neutrons and protons from each other. For simplicity assume that the coin is entirely made of ${}^{63}_{29}Cu$ atoms (of mass 62.92960 u).
Given m_p = 1.007825u and m_n = 1.008665u.

OR

Draw the graph showing the variation of binding energy per nucleon with mass number. Write two inferences which can be drawn from this graph.

23. Charges (+*q*) and (–*q*) are placed at the points A and B respectively which are a distance 2L apart. C is the midpoint between A and B. What is the work done in moving a charge +Q along the semicircle CRD.



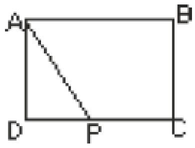
24. The total energy of an electron in the first excited state of the hydrogen atom is about –3.4 eV.

a. What is the kinetic energy of the electron in this state?

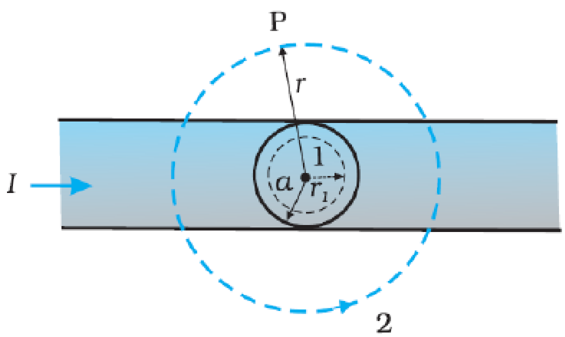
b. What is the potential energy of the electron in this state?

c. Which of the answers above would change if the choice of the zero of potential energy is changed?

25. A wire of uniform cross-section and resistance 4 ohm is bent in the shape of square ABCD. Point A is connected to a point P on DC by a wire AP of resistance 1 ohm. When a potential difference is applied between A and C, the points B and P are seen to be at the same potential. What is the resistance of the part DP?



26. The given figure shows a long straight wire of a circular cross-section (radius *a*) carrying steady current *I*. The current *I* is uniformly distributed across this cross-section. Calculate the magnetic field in the region $r < a$ and $r > a$.



27. Identify the part of the electromagnetic spectrum which:

a) produces heating effect,
b) is absorbed by the ozone layer in the atmosphere,
c) is used for studying crystal structure.

Write any one method of the production of each of the above radiations.

28. a. Define mutual inductance and write its SI unit.

b. Two circular loops, one of small radius *r* and other of larger radius R, such that R >> *r*, are placed coaxially with centres coinciding. Obtain the mutual inductance of the arrangement.

OR

Two long straight parallel current carrying conductors are kept 'a' distant apart in air. The direction of current in both the conductors is same. Find the magnitude of force per unit length and direction of the force between them. Hence define one ampere.

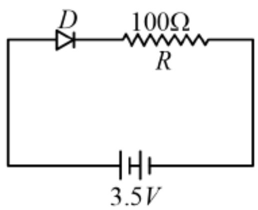
SECTION-D

Case Study Based Questions

29. **Read the following paragraph and answer the questions that follow.**

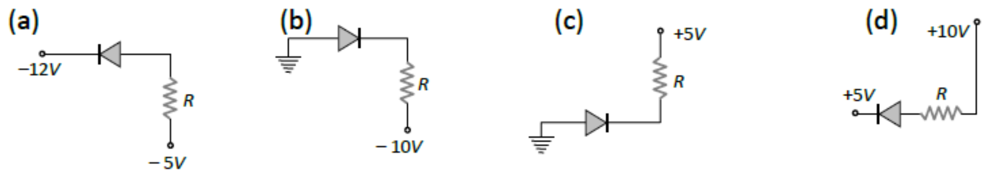
A semiconductor diode is basically a pn junction with metallic contacts provided at the ends for the application of an external voltage. It is a two terminal device. When an external voltage is applied across a semiconductor diode such that p-side is connected to the positive terminal of the battery and n-side to the negative terminal, it is said to be forward biased. When an external voltage is applied across the diode such that n-side is positive and p-side is negative, it is said to be reverse biased. An ideal diode is one whose resistance in forward biasing is zero and the resistance is infinite in reverse biasing. When the diode is forward biased, it is found that beyond forward voltage called knee voltage, the conductivity is very high. When the biasing voltage is more than the knee voltage the potential barrier is overcome and the current increases rapidly with increase in forward voltage. When the diode is reverse biased, the reverse bias voltage produces a very small current about a few microamperes which almost remains constant with bias. This small current is reverse saturation current.

i. In the given figure, a diode *D* is connected to an external resistance $R = 100\ \Omega$ and an emf of 3.5 *V*. If the barrier potential developed across the diode is 0.5 *V*, the current in the circuit will be:



(a) 40 mA (b) 20 mA (c) 35 mA (d) 30 mA

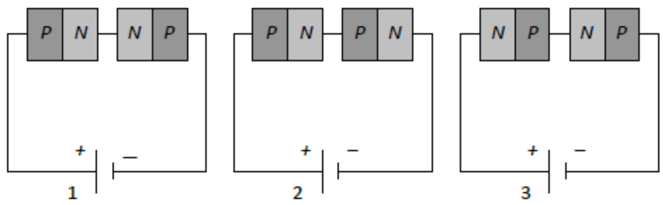
ii. In which of the following figures, the pn diode is reverse biased?



iii. Based on the V-I characteristics of the diode, we can classify diode as
(a) bilateral device (b) ohmic device
(c) non-ohmic device (d) passive element

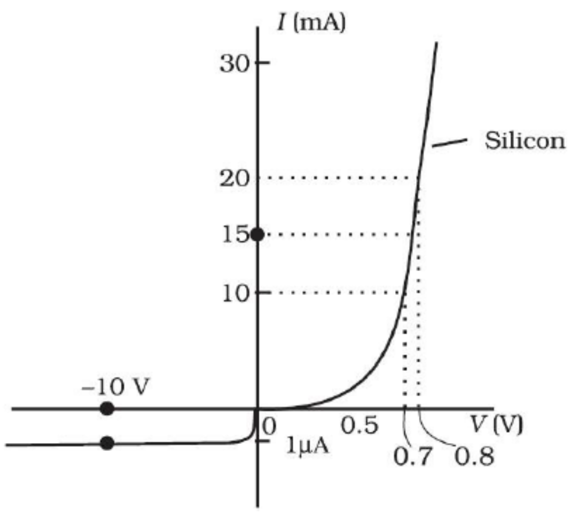
OR

Two identical *PN* junctions can be connected in series by three different methods as shown in the figure. If the potential difference in the junctions is the same, then the correct connections will be



(a) in the circuits (1) and (2) (b) in the circuits (2) and (3)
(c) in the circuits (1) and (3) (d) only in the circuit (1)

iv.



The V-I characteristic of a diode is shown in the figure. The ratio of the resistance of the diode at I = 15 mA to the resistance at V = -10 V is
(a) 100 (b) 10^6 (c) 10 (d) 10^{-6}

30. **Read the following paragraph and answer the questions that follow.**

Types of Lenses and their combination

A convex or converging lens is thicker at the centre than at the edges. It converges a beam of light on refraction through it. It has a real focus. Convex lens is of three types: Double convex lens, Plano convex lens and Concavo-convex lens.

Concave lens is thinner at the centre than at the edges. It diverges a beam of light on refraction through it. It has a virtual focus. Concave lenses are of three types: Double concave lens, Plano concave lens and Convexo-concave lens.

When two thin lenses of focal lengths f_1 and f_2 are placed in contact with each other along their common principal axis, then the two lens system is regarded as a single lens of focal length *f* and

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

If several thin lenses of focal length f_1, f_2, ... f_n are placed in contact, then the effective focal length of the combination is given by

$$\frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2}+.....+\frac{1}{f_n}$$

and in terms of power, we can write

$$P = P_1 + P_2 + ... + P_n$$

The value of focal length and power of a lens must be used with proper sign consideration.

i. Two thin lenses are kept coaxially in contact with each other and the focal length of the combination is 80 cm. If the focal length of one lens is 20 cm, the focal length of the other would be
(a) -26.7cm (b) 60cm (c) 80cm (d) 30cm

ii. A spherical air bubble is embedded in a piece of glass. For a ray of light passing through the bubble, it behaves like a
(a) converging lens
(b) diverging lens
(c) mirror
(d) thin plane sheet of glass

iii. Lens generally used in magnifying glass is
(a) single concave lens
(b) single convex lens
(c) combination of convex lens of lower power and concave lens of lower focal length
(d) Planoconcave lens

iv. The magnification of an image by a convex lens is positive only when the object is placed
(a) at its focus F
(b) between F and 2F
(c) at 2F
(d) between F and optical centre

OR

A convex lens of 20 cm focal length forms a real image which is three times magnified. The distance of the object from the lens is
(a) 13.33 cm (b) 14 cm (c) 26.66 cm (d) 25 cm

SECTION-E

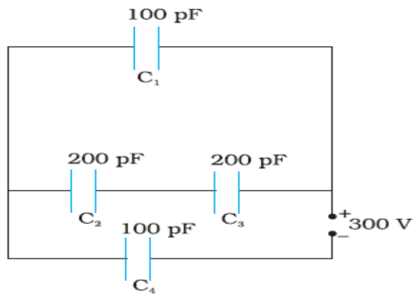
31. i. Draw a ray diagram for the formation of image of a point object by a thin double convex lens having radii of curvature R_1 and R_2. Hence derive lens maker's formula.

ii A converging lens has a focal length of 10 cm in air. It is made of a material of refractive index 1.6. If it is immersed in a liquid of refractive index 1.3, find its new focal length.

OR

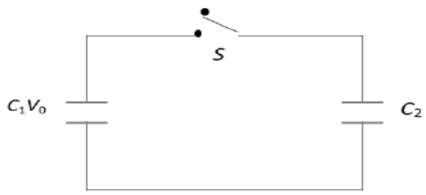
i. Define a wavefront. How is it different from a ray?
ii. Using Huygens's construction of secondary wavelets draw a diagram showing the passage of a plane wavefront from a denser to a rarer medium. Using it verify Snell's law.
iii. In a double slit experiment using light of wavelength 600nm and the angular width of the fringe formed on a distant screen is 0.1°. Find the spacing between the two slits.
iv. Write two differences between interference pattern and diffraction pattern.

32. i. Derive an expression for the capacitance of a parallel plate capacitor with air present between the two plates.
ii. Obtain the equivalent capacitance of the network shown in figure. For a 300 V supply, determine the charge on each capacitor.



OR

i. A dielectric slab of thickness 't' is kept between the plates of a parallel plate capacitor with plate separation 'd' ($t < d$). Derive the expression for the capacitance of the capacitor.
ii. A capacitor of capacity C_1 is charged to the potential of V_o. On disconnecting with the battery, it is connected with an uncharged capacitor of capacity C_2 as shown in the adjoining figure. Find the ratio of energies before and after the connection of switch S.



33.a. Draw graphs showing the variations of inductive reactance and capacitive reactance with frequency of applied ac source.
b. Draw the phasor diagram for a series LRC circuit connected to an AC source.

c. When an alternating voltage of 220V is applied across a device X, a current of 0.25A flows which lags behind the applied voltage in phase by π/2 radian. If the same voltage is applied across another device Y, the same current flows but now it is in phase with the applied voltage.
(i) Name the devices X and Y.
(ii) Calculate the current flowing in the circuit when the same voltage is applied across the series combination of X and Y.

OR

a. A series LCR circuit is connected to an ac source. Using the phasor diagram, derive the expression for the impedance of the circuit.
b. Plot a graph to show the variation of current with frequency of the ac source, explaining the nature of its variation for two different resistances R_1 and R_2 ($R_1 < R_2$) at resonance.

Class: XII Session 2023-24
SUBJECT: PHYSICS(THEORY)
MARKING SCHEME
SECTION A

A1: c **1M**

A2: c $q = \tau/[(2a)\, E \sin\theta] = \frac{4}{2\times10^{-2}\times 2\times 10^{5}\sin 30°}$ **1M**

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

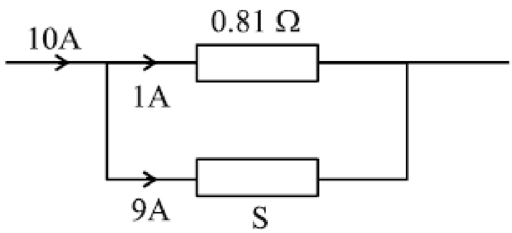
A3: d Higher the frequency, greater is the stopping potential **1M**

A4: c **1M**

A5: b **1M**

A6: d **1M**

A7: b **1M**



9 x S = 1 × 0.81

$S = \frac{0.81}{9} = 0.09\ \Omega$

A8: a **1M**

A9: d **1M**

A10: a **1M**

A11: d $e = \frac{\Delta\Phi}{\Delta t}, I = \frac{1}{R}\frac{\Delta\Phi}{\Delta t}$ **1M**

$I\ \Delta t = \frac{\Delta\Phi}{R}$ = Area under $I - t$ graph, R = 100 ohm

$\therefore \quad \Delta\Phi = 100\times\frac{1}{2}\times10\times0.5 = 250$ Wb.

A12: b **1M**

A13: a **1M**

A14: a **1M**

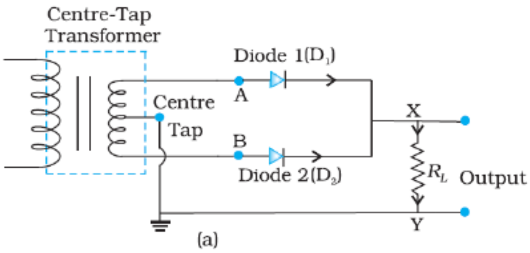
A15: c **1M**

Q16: c **1M**

SECTION B

A17: (a) Rectifier **1M**

(b) Circuit diagram of full wave rectifier **1M**



A18: As λ = h / mv , v= h /mλ -----------------(i) 1/2M

Energy of photon E = hc /λ 1/2M

& Kinetic energy of electron K =1/2 mv² = ½ mh² / m² λ² --------------(ii) 1/2M

Simplifying equation i & ii we get E / K = 2λmc /h 1/2M

A19: Here angle of prism A = 60°, angle of incidence *i* = angle of emergence *e* and under this condition angle of deviation is minimum

$\therefore$ $i = e = \frac{3}{4}A = \frac{3}{4} \times 60° = 45°$ and $i + e = A + D$,

hence $D_m = 2i - A = 2 \times 45° - 60° = 30°$ 1M

$\therefore$ Refractive index of glass prism

$$n = \frac{\sin\left(\frac{A+D_m}{2}\right)}{\sin\left(\frac{A}{2}\right)} = \frac{\sin\left(\frac{60°+30°}{2}\right)}{\sin\left(\frac{60°}{2}\right)} = \frac{\sin 45°}{\sin 30°} = \frac{1/\sqrt{2}}{1/2} = \sqrt{2}.$$ 1M

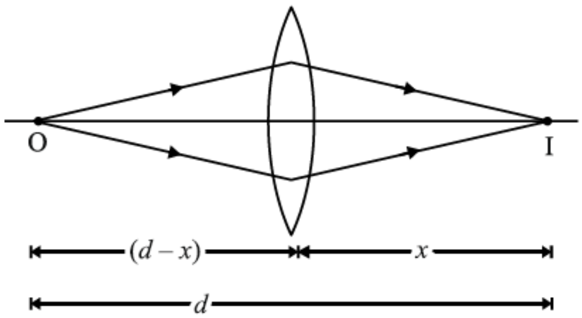
A20:Given: V=230 V, I_0= 3.2A, I=2.8A, T_0 =27 ⁰C, α=1.70 × 10^{-4} °C^{-1}.

Using equation $R = R_0 (1+ \alpha \Delta T)$ ½ M

i.e $V/I = \{V/I_0\} [1 + \alpha \Delta T]$ ½ M

and solving ΔT= 840 , i.e. T = 840 + 27 = 867 ⁰C 1M

A21: Let *d* be the least distance between object and image for a real image formation.



½ M

$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$, $\frac{1}{f} = \frac{1}{x} + \frac{1}{d-x} = \frac{d}{x(d-x)}$ ½ M

$fd = xd - x^2$, $x^2 - dx + fd = 0$, $x = \frac{d \pm \sqrt{d^2 - 4fd}}{2}$ ½ M

For real roots of *x*, $d^2 - 4fd \geq 0$ ½ M

$d \geq 4f$.

OR

Let f_o and f_e be the focal length of the objective and eyepiece respectively.

For normal adjustment the distance from objective to eyepiece is $f_o + f_e$.

Taking the line on the objective as object and eyepiece as lens

$u = -(f_o + f_e)$ and $f = f_e$

$$\frac{1}{v} - \frac{1}{[-\{fo + fe\}]} = \frac{1}{fe} \Rightarrow v = \left(\frac{f_o + f_e}{f_o}\right) f_e$$ 1M

Linear magnification (eyepiece) = $\frac{v}{u} = \frac{Image\ size}{Object\ size} = \frac{fe}{fo} = \frac{l}{L}$ ½ M

∴ Angular magnification of telescope

$M = \frac{f_0}{f_e} = \frac{L}{l}$ ½ M

SECTION C

A22: Number of atoms in 3 gram of Cu coin = $(6.023 \times 10^{23} \times 3) / 63 = 2.86 \times 10^{22}$ ½ M

Each atom has 29 Protons & 34 Neutrons

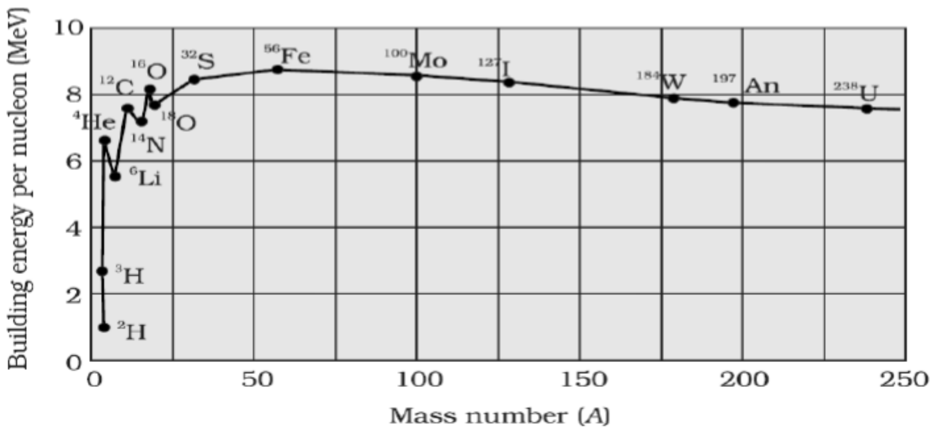
Thus Mass defect $\Delta m = 29 \times 1.00783 + 34 \times 1.00867 - 62.92960\ u = 0.59225u$ 1M

Nuclear energy required for one atom =0.59225 X 931.5 MeV ½ M

Nuclear energy required for 3 gram of Cu =0.59225 X 931.5 X 2.86X 10^{22}MeV

= 1.58 X 10^{25} MeV 1M

OR



The binding energy per nucleon as a function of mass number.

2 M

(i) the binding energy per nucleon, E_{bn}, is practically constant, i.e. practically independent of the atomic number for nuclei of middle mass number (30 < A < 170). The curve has a maximum of about 8.75 MeV for *A* = 56 and has a value of 7.6 MeV for *A* = 238.

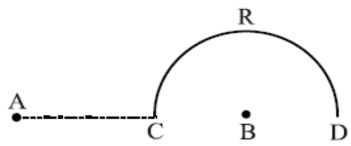
(ii) E_{bn} is lower for both light nuclei (*A*<30) and heavy nuclei (*A*>170).

We can draw some conclusions from these two observations:

(i) The force is attractive and sufficiently strong to produce a binding energy of a few MeV per nucleon.

(ii) The constancy of the binding energy in the range 30 < A < 170 is a consequence of the fact that the nuclear force is short-ranged. **1M**

A23:



$V_C = 0$, **1M**

$V_D = \frac{1}{4\pi\varepsilon_0}\left[\frac{q}{3L} - \frac{q}{L}\right] = \frac{-q}{6\pi\varepsilon_0 L}$ **1M**

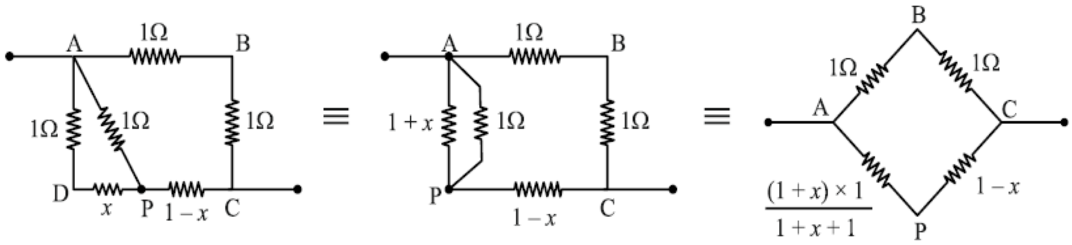
$W = Q\,[V_D - V_C] = \frac{-Qq}{6\pi\varepsilon_0 L}$ **1M**

A24 : formula K=-E , U = -2K **1M**

(a) K = 3.4 eV & (b) U= -6.8 eV **1M**

(c) The kinetic energy of the electron will not change. The value of potential energy and consequently, the value of total energy of the electron will change. **1M**

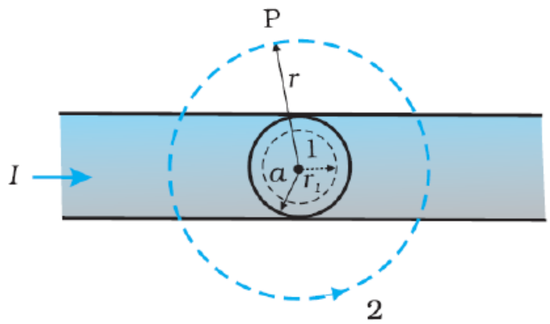
A25:



1.5M

As the points B and P are at the same potential, $\frac{1}{1} = \frac{\frac{(1+x)}{(2+x)}}{(1-x)} \Rightarrow x = (\sqrt{2} - 1)\ ohm$ **1.5M**

A26:



(a) Consider the case $r > a$. The Amperian loop, labelled 2, is a circle concentric with the cross-section. For this loop, $L = 2\pi r$

Using Ampere circuital Law, we can write,

$B\,(2\pi r) = \mu_0 I$, $B = \frac{\mu_0 I}{2\pi r}$, $B \propto \frac{1}{r}$ $(r > a)$ **1.5 M**

(b)Consider the case $r < a$. The Amperian loop is a circle labelled 1. For this loop, taking the radius of the circle to be r, $L = 2\pi r$

Now the current enclosed I_e is not I, but is less than this value. Since the current distribution is uniform, the current enclosed is,

$I_e = I\left(\frac{\pi r^2}{\pi a^2}\right) = \frac{Ir^2}{a^2}$ Using Ampere's law, $B\,(2\pi r) = \mu_0 \frac{Ir^2}{a^2}$

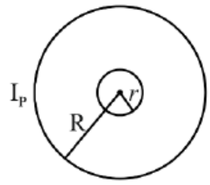
$B = \left(\frac{\mu_0 I}{2\pi a^2}\right) r$ $B \propto r$ $(r < a)$ **1.5M**

A27: (a) Infrared (b) Ultraviolet (c) X rays ½ + ½ + ½ M

Any one method of the production of each one ½ + ½ + ½ M

A28 **(a)** : Definition and S.I. Unit. ½ + ½ **M**

(b)



Let a current I_P flow through the circular loop of radius R. The magnetic induction at the centre of the loop is

$$B_P = \frac{\mu_0 I_P}{2R}$$ **½ M**

As, $r << R$, the magnetic induction B_P may be considered to be constant over the entire cross sectional area of inner loop of radius *r*. Hence magnetic flux linked with the smaller loop will be

$$\phi_S = B_P A_S = \frac{\mu_0 I_P}{2R}\pi r^2$$ **½ M**

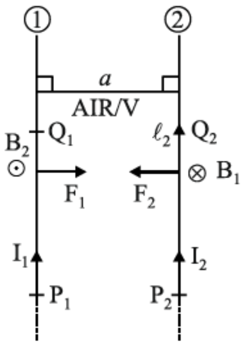
Also, $$\phi_S = M\, I_P$$ **½ M**

∴ $$M = \frac{\phi_S}{I_P} = \frac{\mu_0 \pi r^2}{2R}$$ **½ M**

OR

The magnetic induction B_1 set up by the current I_1 flowing in first conductor at a point somewhere in the middle of second conductor is

$$B_1 = \frac{\mu_0 I_1}{2\pi a} \quad ...(1)$$ ½ **M**



The magnetic force acting on the portion P_2Q_2 of length ℓ_2 of second conductor is

$$F_2 = I_2\, \ell_2\, B_1 \sin 90° \quad ...(2)$$

From equation (1) and (2),

$$F_2 = \frac{\mu_0 I_1 I_2 \ell_2}{2\pi a}$$, towards first conductor ½ M

$$\frac{F_2}{\ell_2} = \frac{\mu_0 I_1 I_2}{2\pi a} \quad ...(3)$$

The magnetic induction B_2 set up by the current I_2 flowing in second conductor at a point somewhere in the middle of first conductor is

$$B_2 = \frac{\mu_0 I_2}{2\pi a} \quad ...(4) \qquad ½ M$$

The magnetic force acting on the portion P_1Q_1 of length ℓ_1 of first conductor is

$$F_1 = I_1\ell_1 B_2 \sin 90° \quad ...(5)$$

From equation (3) and (5)

$$F_1 = \frac{\mu_0 I_1 I_2 \ell_1}{2\pi a}$$, towards second conductor ½ M

$$\frac{F_1}{\ell_1} = \frac{\mu_0 I_1 I_2}{2\pi a} \quad ...(6)$$

The standard definition of 1A

If $I_1 = I_2 = 1A$

$\ell_1 = \ell_2 = 1m$

$a = 1m$ in V/A then $\frac{F_1}{\ell_1} = \frac{F_2}{\ell_2} = \frac{\mu_0 \times 1 \times 1}{2\pi \times 1} = 2\times 10^{-7}$ N/m

∴ One ampere is that electric current which when flows in each one of the two infinitely long straight parallel conductors placed 1m apart in vacuum causes each one of them to experience a force of 2×10^{-7} N/m. **1**M

SECTION D

A29 (i) d (ii) c (iii) c OR b (iv) d

A30: (i) a (ii) b (iii) b (iv) d OR c

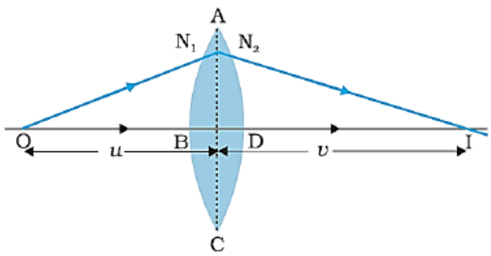
SECTION E

A31: i. DIAGRAM/S : 1M

DERIVATION : 2M

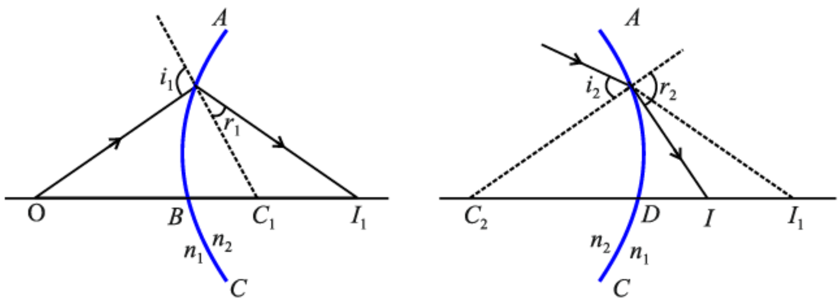
NUMERICAL : 2 M

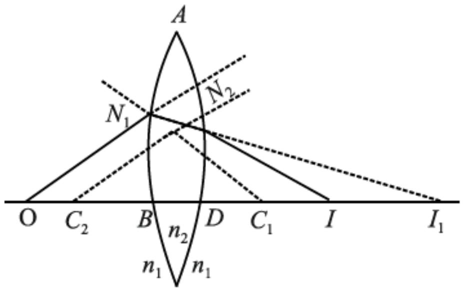
Lens maker's Formula



When a ray refracts from a lens (double convex), in above figure, then its image formation can be seen in term of two steps :

Step 1: The first refracting surface forms the image I_1 of the object O





Step 2: The image of object O for first surface acts like a virtual object for the second surface.
Now for the first surface ABC, ray will move from rarer to denser medium, then

$$\frac{n_2}{BI_1}+\frac{n_1}{OB}=\frac{n_2-n_1}{BC_1} \qquad \text{...(i)}$$ ½ M

Similarly for the second interface, ADC we can write.

$$\frac{n_1}{DI}-\frac{n_2}{DI_1}=\frac{n_2-n_1}{DC_2} \qquad \text{...(ii)}$$ ½ M

DI_1 is negative as distance is measured against the direction of incident light.
Adding equation (1) and equation (2), we get

$$\frac{n_2}{BI_1}+\frac{n_1}{OB}+\frac{n_1}{DI}-\frac{n_2}{DI_1}=\frac{n_2-n_1}{BC_1}+\frac{n_2-n_1}{DC_2}$$

or $$\frac{n_1}{DI}+\frac{n_1}{OB}=(n_2-n_1)\left(\frac{1}{BC_1}+\frac{1}{DC_2}\right)$$ ...(iii) ($\because$ for thin lens $BI_1 = DI_1$)

Now, if we assume the object to be at infinity *i.e.* $OB \to \infty$, then its image will form at focus F (with focal length f), *i.e.* ½ M

$DI = f$, thus equation (iii) can be rewritten as

$$\frac{n_1}{f}+\frac{n_1}{\infty}=(n_2-n_1)\left(\frac{1}{BC_1}+\frac{1}{DC_2}\right)$$

or $$\frac{n_1}{f}=(n_2-n_1)\left(\frac{1}{BC_1}+\frac{1}{DC_2}\right) \qquad \text{...(iv)}$$

Now according to the sign conventions

$BC_1 = +R_1$ and $DC_2 = -R_2$ ...(v) ½ M

Substituting equation (v) in equation (iv), we get

$$\frac{n_1}{f}=(n_2-n_1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\frac{1}{f}=\left(\frac{n_2}{n_1}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\frac{1}{f}=(n_{21}-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

(ii) $$\frac{1}{f_a}=(1.6-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right) \qquad \text{...(1)}$$ **1M**

$$\frac{1}{f_\ell}=\left[\frac{1.6}{1.3}-1\right]\left(\frac{1}{R_1}-\frac{1}{R_2}\right) \qquad \text{....(2)}$$ **1M**

From equation (1) and (2)

$$\frac{f_\ell}{f_a}=\left[\frac{0.6}{0.3}\times 1.3\right] \Rightarrow f_\ell = 2.6\times 10\,\text{cm} \Rightarrow f_\ell = 26\,\text{cm}$$

OR

(i) A wavefront is defined as a surface of constant phase.

(a) The ray indicates the direction of propagation of wave while the wavefront is the surface of constant phase.

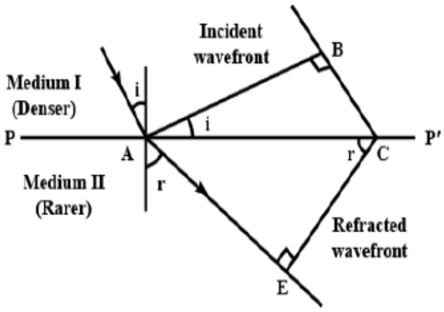
(b) The ray at each point of a wavefront is normal to the wavefront at that point.

1M

(ii) AB: Incident Plane Wave Front & CE is Refracted Wave front . **2M**

Sin i =BC/AC & Sin r = AE /AC

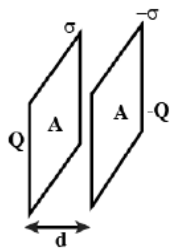
Sin i / Sinr = BC /AE = v_1 /v_2 = constant



(iii) ϴ = λ /a i.e. $a=\frac{\lambda}{\theta}=\frac{6\times10^{-7}}{0.1\times\frac{\pi}{180}}=3.4\times10^{-4}\,\text{m}$ **1M**

(iv) Two differences between interference pattern and diffraction pattern **1M**

A32: (i) Derivation of the expression for the capacitance **2M**



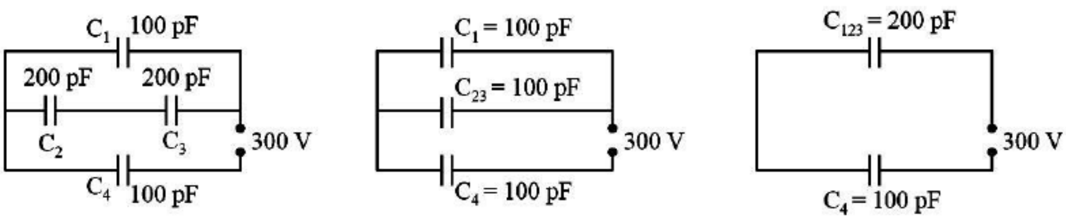
Let the two plates be kept parallel to each other separated by a distance d and cross-sectional area of each plate is A. Electric field by a single thin plate E = $\sigma/2\epsilon_0$

Total electric field between the plates E= σ/ϵ_0 = Q/A ϵ_0

Potential difference between the plates V=Ed = [Q/A ϵ_0] d.

Capacitance C= Q / V = Aϵ_0 / d

(ii)



1 M

The equivalent capacitance = $\frac{200}{3}$ pF

charge on C_4 = $\frac{200}{3} \times 10^{-12} \times 300$= 2 × 10^{-8} C, **½ M**

potential difference across C_4 = $\frac{200\times10^{-12}\times300}{3\times100\times10^{-12}}$ = 200 V

potential difference across C_1 = 300 – 200 = 100 V

charge on C_1 = 100 × 10^{-12} × 100 = 1 × 10^{-8} C **½ M**

potential difference across C_2 and C_3 series combination = 100 V

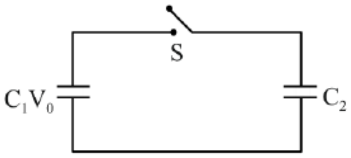
potential difference across C_2 and C_3 each = 50 V

charge on C_2 and C_3 each = 200 × 10^{-12} × 50 = 1 × 10^{-8} C **½+½ M**

OR

(i) Derivation of the expression for capacitance with dielectric slab ($t < d$) **3M**

(ii)



Before the connection of switch S,

Initial energy U_i = $\frac{1}{2}C_1V_0^2 + \frac{1}{2}C_2 0^2 = \frac{1}{2}C_1V_0^2$ **½ M**

After the connection of switch S

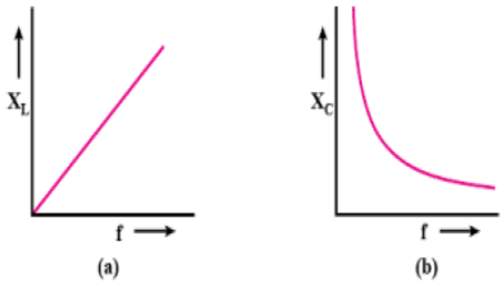
common potential V = $\frac{C_1V_1 + C_2V_2}{C_1 + C_2} = \frac{C_1V_0}{C_1 + C_2}$ **½ M**

Final energy = U_f = $\frac{1}{2}(C_1 + C_2)\frac{(C_1V_0)^2}{(C_1 + C_2)^2} = \frac{1}{2}\frac{C_1^2V_0^2}{(C_1 + C_2)}$ **½ M**

$U_f : U_i = C_1/(C_1 + C_2)$ **½ M**

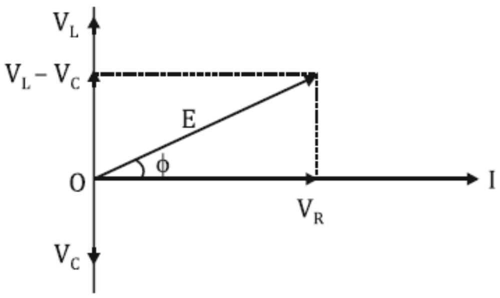
A33:

(a)



½ + ½ M

(b)



1M

(c)(i) In device X, Current lags behind the voltage by π /2, X is an inductor

In device Y, Current in phase with the applied voltage, Y is resistor **½ + ½ M**

(ii) We are given that

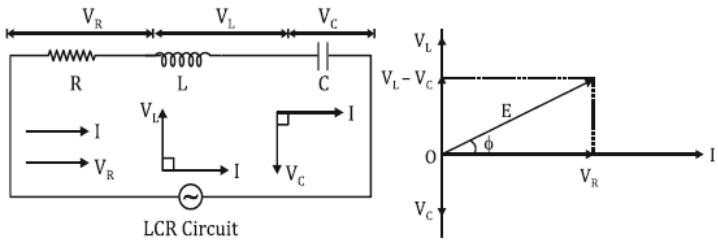
$0.25=220/X_L$, $X_L = 880\Omega$, Also $0.25=220/R$, $R = 880\Omega$ **1M**

For the series combination of X and Y,

Equivalent impedance $Z = 880\sqrt{2}\ \Omega$, $I = 0.177$ A **1M**

OR

a.



1M

$E = E_0 \sin\omega t$ is applied to a series LCR circuit. Since all three of them are connected in series the current through them is same. But the voltage across each element has a different phase relation with current. The potential difference V_L, V_C and V_R across L, C and R at any instant is given by

$V_L = IX_L$, $V_C = IX_C$ and $V_R = IR$, where I is the current at that instant.

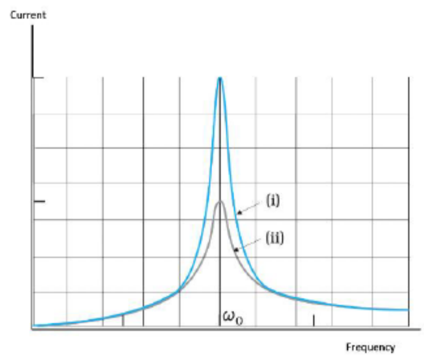
V_R is in phase with I. V_L leads I by 90° and V_C lags behind I by 90° so the phasor diagram will be as shown Assuming $V_L > V_C$, the applied emf E which is equal to resultant of potential drop across R, L & C is given as

$E^2 = I^2 [R^2 + (X_L - X_C)^2]$

Or $I = \frac{E}{\sqrt{[R^2 + (X_L - X_C)2\ ]}} = \frac{E}{Z}$, where Z is Impedance. **3M**

Emf leads current by a phase angle φ as $\tan\varphi = \frac{V_L - V_C}{R} = \frac{X_L - X_C}{R}$

b. The curve (i) is for R_1 and the curve (ii) is for R_2 **1M**



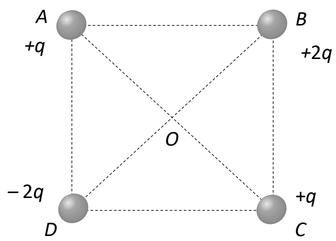
COMPETENCY FOCUSED QUESTIONS

UNIT-I: ELECTROSTATICS

MCQs (Chapters 1 & 2)

ELECTRIC CHARGE & COULOMB'S LAW:

1. A body has – 80 μC of charge. Number of additional electrons in it will be
   (a) 8×10^{-5} (b) 80×10^{-17}
   (c) 5×10^{14} (d) 1.28×10^{-17}
2. $+2$ C and $+6$ C two charges are repelling each other with a force of 12N. If each charge is given $-2C$ of charge, then the value of the force will be
   (a) $4N$ (Attractive) (b) $4N$ (Repulsive)
   (c) $8N$ (Repulsive) (d) Zero
3. A charge **Q** is divided into two parts of **q** and **(Q - q)**. If the coulomb repulsion between them when they are separated is to be maximum, the ratio of $\frac{Q}{q}$ should be
   (a) 2 (b) $1/2$
   (c) 4 (d) $1/4$
4. Four charges are arranged at the corners of a square $ABCD$ as shown in the adjoining figure. The force on the charge kept at the centre O is

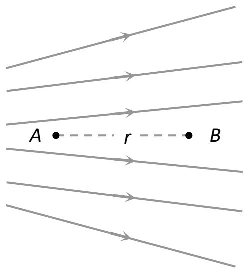


   (a) Zero (b) Along the diagonal AC
   (c) Along the diagonal BD (d) Perpendicular to side AB
5. Two small spheres each having the charge $+Q$ are suspended by insulating threads of length L from a hook. This arrangement is taken in space where there is no gravitational effect, then the angle between the two suspensions and the tension in each will be
   (a) $180^o, \frac{1}{4\pi\varepsilon_0}\frac{Q^2}{(2L)^2}$ (b) $90^o, \frac{1}{4\pi\varepsilon_0}\frac{Q^2}{L^2}$
   (c) $180^o, \frac{1}{4\pi\varepsilon_0}\frac{Q^2}{2L^2}$ (d) $180^o, \frac{1}{4\pi\varepsilon_0}\frac{Q^2}{L^2}$

ELECTRIC FIELD & ELECTRIC POTENTIAL:

6. Charges of $+\frac{10}{3}\times10^{-9}C$ are placed at each of the four corners of a square of side 8 cm. The potential at the intersection of the diagonals is
   (a) $150\sqrt{2}V$ (b) $1500\sqrt{2}V$
   (c) $900\sqrt{2}V$ (d) $900V$
7. Three charges $2q, -q, -q$ are located at the vertices of an equilateral triangle. At the centroid of the triangle
   (a) The field is zero but potential is non-zero (b) The field is non-zero but potential is zero
   (c) Both field and potential are zero (d) Both field and potential are non-zero

8. Figure shows the electric lines of force emerging from a charged body. If the electric field at A and B are E_A and E_B respectively and if the displacement between A and B is r then

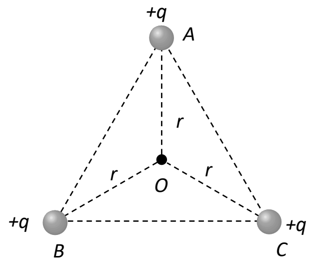


(a) $E_A > E_B$ (b) $E_A < E_B$ (c) $E_A = \frac{E_B}{r}$ (d) $E_A = \frac{E_B}{r^2}$

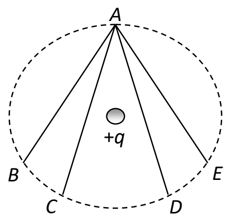
9. ABC is an equilateral triangle. Charges $+q$ are placed at each corner. The electric intensity at O will be

(a) $\frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$ (b) $\frac{1}{4\pi\varepsilon_0}\frac{q}{r}$

(c) Zero (d) $\frac{1}{4\pi\varepsilon_0}\frac{3q}{r^2}$



10. In the electric field of a point charge q, a certain charge is carried from point A to B, C, D & E. Then the work done



(a) is least along the path AB (b) is least along the path AD

(c) is zero along all the paths AB, AC, AD and AE (d) is least along AE

11. The magnitude of electric field intensity E is such that, an electron placed in it would experience an electrical force equal to its weight is given by

(a) mge (b) $\frac{mg}{e}$ (c) $\frac{e}{mg}$ (d) $\frac{e^2}{m^2}g$

12. An electron and a proton are in a uniform electric field, the ratio of their accelerations will be

(a) Zero

(b) Unity

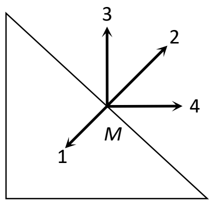
(c) The ratio of the masses of proton and electron

(d) The ratio of the masses of electron and proton

13. Two positive point charges of $12\mu C$ and 8 μC are $10 cm$ apart. The work done in bringing them 4 cm closer is

(a) 5.8 J (b) 5.8 eV (c) 13 J (d) 13 eV

14. Three identical point charges, as shown are placed at the vertices of an isosceles right angled triangle. Which of the numbered vectors coincides in direction with the electric? field at the mid-point M of the hypotenuse.



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

15. The displacement of a charge Q in the electric field $E = e_1\hat{i} + e_2\hat{j} + e_3\hat{k}$ is $\hat{r} = a\hat{i} + b\hat{j}$. The work done is

(a) $Q(ae_1 + be_2)$ (b) $Q\sqrt{(ae_1)^2 + (be_2)^2}$

(c) $Q(e_1 + e_2)\sqrt{a^2 + b^2}$ (d) $Q(\sqrt{e_1^2 + e_2^2})\ (a + b)$

16. The potential at a point, due to a positive charge of $100\mu C$ at a distance of 9*m*, is

(a) $10^4\,V$ (b) $10^5\,V$ (c) $10^6\,V$ (d) $10^7\,V$

17. A drop of $10^{-6}\,kg$ water carries $10^{-6}\,C$ charge. What electric field should be applied to balance its weight (assume $g = 10m/s^2$)

(a) 10 V/m upward (b) 10 V/m downward

(c) 0.1 V/m downward (d) 0.1 V/m upward

18. A simple pendulum of period T has a metal bob which is negatively charged. If it is allowed to oscillate above a positively charged metal plate, its period will

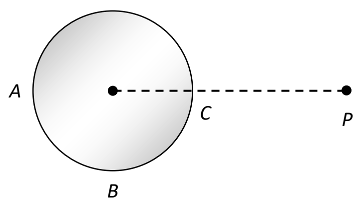
(a) Remains equal to T (b) Less than T

(c) Greater than T (d) Infinite

19. A charged particle of mass m and charge q is released from rest in a uniform electric field E. Neglecting the effect of gravity, the kinetic energy of the charged particle after 't' second is

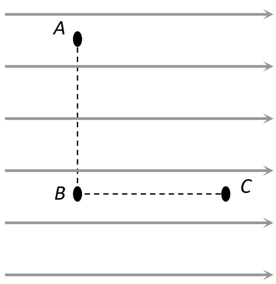
(a) $\frac{Eq^2m}{2t^2}$ (b) $\frac{2E^2t^2}{mq}$ (c) $\frac{E^2q^2t^2}{2m}$ (d) $\frac{Eqm}{t}$

20. A hollow conducting sphere is placed in an electric field produced by a point charge placed at P as shown in figure. Let V_A, V_B, V_C be the potentials at points A, B and C respectively. Then



(a) $V_C > V_B$ (b) $V_B > V_C$ (c) $V_A > V_B$ (d) $V_A = V_C$

21. Figure shows three points *A*, *B* and *C* in a region of uniform electric field $\vec{E}$. The line *AB* is perpendicular and *BC* is parallel to the field lines. Then which of the following holds good. Where V_A, V_B and V_C represent the electric potential at points *A*, *B* and *C* respectively



(a) $V_A = V_B = V_C$ (b) $V_A = V_B > V_C$ (c) $V_A = V_B < V_C$ (d) $V_A > V_B = V_C$

22. An infinite line charge produces a field of $7.182 \times 10^8\ N/C$ at a distance of 2 *cm*. The linear charge density is
    (a) $7.27 \times 10^{-4}\ C/m$ (b) $7.98 \times 10^{-4}\ C/m$ (c) $7.11 \times 10^{-4}\ C/m$ (d) $7.04 \times 10^{-4}\ C/m$

23. Two infinitely long parallel conducting plates having surface charge densities $+\sigma$ and $-\sigma$ respectively, are separated by a small distance. The medium between the plates is vacuum. If ε_0 is the dielectric permittivity of vacuum, then the electric field in the region between the plates is
    (a) $0\ volts/meter$ (b) $\frac{\sigma}{2\varepsilon_o}\ volts/meter$
    (c) $\frac{\sigma}{\varepsilon_o}\ volts/meter$ (d) $\frac{2\sigma}{\varepsilon_o}\ volts/meter$

24. At a point 20 *cm* from the centre of a uniformly charged dielectric sphere of radius 10 *cm*, the electric field is 100 *V/m*. The electric field at 3 *cm* from the centre of the sphere will be
    (a) 150 *V/m* (b) 125 *V/m* (c) 120 *V/m* (d) Zero

ELECTRIC DIPOLE:

25. An electric dipole is kept in non-uniform electric field. It experiences
    (a) a force and a torque (b) a force but not a torque
    (c) a torque but not a force (d) neither a force nor a torque

26. An electric dipole consisting of two opposite charges of $2 \times 10^{-6} C$ each separated by a distance of $3 cm$ is placed in an electric field of 2×10^5 *N/C*. The maximum torque on the dipole will be
    (a) $12 \times 10^{-1}\ N\ m$ (b) $12 \times 10^{-3}\ N\ m$
    (c) $24 \times 10^{-1}\ N\ m$ (d) $24 \times 10^{-3}\ N\ m$

27. An electric dipole is placed at an angle of 30° with an electric field of intensity 2 x 10^5 NC^{-1}. It experiences a torque equal to 4 Nm. Calculate the magnitude of charge on the dipole, if the dipole length is 2cm.
    (a) 6 mC (b) 4 mC (c) 2 mC (d) 8 mC

28. The electric field at a point on equatorial line of a dipole and direction of the dipole moment
    (a) will be parallel (b) will be in opposite direction
    (c) will be perpendicular (d) are not related

29. Electric potential at an equatorial point of a small dipole with dipole moment P (*r*-distance from the dipole) is
    (a) Zero (b) $\frac{P}{4\pi\varepsilon_0 r^2}$ (c) $\frac{P}{4\pi\varepsilon_0 r^3}$ (d) $\frac{2P}{4\pi\varepsilon_0 r^3}$

30. The potential at a point due to an electric dipole will be maximum and minimum when the angles between the axis of the dipole and the line joining the point to the dipole are respectively
    (a) 90^o and 180^o (b) 0^o and 90^o
    (c) 90^o and 0^o (d) 0^o and 180^o

ELECTRIC FLUX& GAUSS LAW:

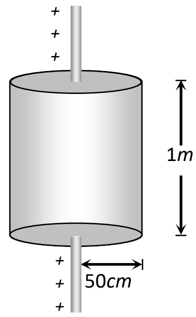
31. A cylinder of radius R and length L is placed in a uniform electric field E parallel to the cylinder axis. The total flux for the surface of the cylinder is given by

(a) $2\pi R^2 E$ (b) $\pi R^2 / E$ (c) $(\pi R^2 - \pi R)/E$ (d) Zero

32. Eight dipoles of charges of magnitude e are placed inside a cube. The total electric flux coming out of the cube will be

(a) $\frac{8e}{\varepsilon_0}$ (b) $\frac{16e}{\varepsilon_0}$ (c) $\frac{e}{\varepsilon_0}$ (d) Zero

33. Electric charge is uniformly distributed along a long straight wire of radius 1*mm*. The charge per *cm* length of the wire is Q *coulomb*. Another cylindrical surface of radius 50 *cm* and length 1*m* symmetrically encloses the wire as shown in the figure. The total electric flux passing through the cylindrical surface is



(a) $\frac{Q}{\varepsilon_0}$

(b) $\frac{100Q}{\varepsilon_0}$

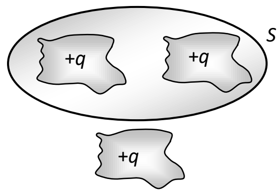
(c) $\frac{10Q}{(\pi\varepsilon_0)}$

(d) $\frac{100Q}{(\pi\varepsilon_0)}$

34. The inward and outward electric flux for a closed surface in units of $N\text{-}m^2/C$ are respectively 8×10^3 and 4×10^3. Then the total charge inside the surface is (where ε_0 = permittivity constant)

(a) $4\times10^3\ C$ (b) $-4\times10^3\ C$ (c) $\frac{(-4\times10^3)}{\varepsilon}\ C$ (d) $-4\times10^3\varepsilon_0 C$

35. Shown below is a distribution of charges. The flux of electric field due to these charges through the surface S is



(a) $3q/\varepsilon_0$ (b) $2q/\varepsilon_0$ (c) q/ε_0 (d) Zero

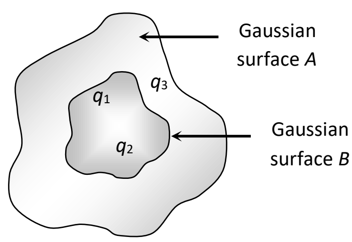
36. The electric flux for Gaussian surface A that enclose the charged particles in free space is (given $q_1 = -14\ nC$, $q_2 = 78.85\ nC$, $q_3 = -56\ nC$)

(a) $10^3\ Nm^2\ C^{-1}$

(b) $10^3\ CN^{-1}\ m^{-2}$

(c) $6.32\times10^3\ Nm^2\ C^{-1}$

(d) $6.32\times10^3\ CN^{-1}\ m^{-2}$



CAPACITANCE:

37. A parallel plate condenser has a capacitance $50\mu F$ in air and $110\mu F$ when immersed in an oil. The dielectric constant K of the oil is
   (a) 0.45 (b) 0.55 (c) 1.10 (d) 2.20

38. The capacity of parallel plate condenser depends on
   (a) The type of metal used (b) The thickness of plates
   (c) The potential applied across the plates (d) The separation between the plates

39. Between the plates of a parallel plate condenser there is $1mm$ thick paper of dielectric constant 4. It is charged at $100\,V$. The electric field in $volt/metre$ between the plates of the capacitor is
   (a) 100 (b) 100000 (c) 25000 (d) 4000000

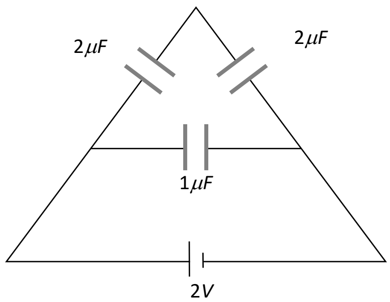
40. A charge of $40\mu C$ is given to a capacitor having capacitance 10μf. The stored energy in ergs is
   (a) 80×10^{-6} (b) 800 (c) 80 (d) 8000

41. A parallel plate capacitor has an electric field of $10^5\,V/m$ between the plates. If the charge on the capacitor plate is $1\mu C$, the force on each capacitor plate is
   (a) $0.5\,N$ (b) $0.05\,N$ (c) $0.005\,N$ (d) None of these

42. The capacitor of capacitance $4\mu F$ and $6\mu F$ are connected in series. A potential difference of $500\,V$ applied to the outer plates of the two capacitor system. Then the charge on each capacitor is numerically
   (a) $6000\,C$ (b) $1200\,C$ (c) $1200\,\mu C$ (d) $6000\,\mu C$

43. A capacitor of $20\mu F$ is charged to $500\,V$ and connected in parallel with another capacitor of $10\mu F$ and charged to $200\,V$. The common potential is
   (a) $200\,V$ (b) $300\,V$ (c) $400\,V$ (d) $500\,V$

44. The charge on any one of the $2\mu F$ capacitors and $1\mu F$ capacitor will be given respectively (in μC) as
   (a) 1, 2
   (b) 2, 1
   (c) 1, 1
   (d) 2, 2



45. When two identical capacitors are in series have $3\mu F$ capacitance and when parallel $12\mu F$. What is the capacitance of each capacitor?
   (a) $6\mu F$ (b) $3\mu F$ (c) $12\mu F$ (d) $9\mu F$

ASSERTION - REASON TYPE QUESTIONS:

Directions: In the following questions, a statement of assertion is followed by a statement of reason.
Mark thecorrect choice as:
(a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of assertion.
(c) If assertion is true but reason is false.
(d) If both assertion and reason are false.

46. **Assertion (A):** In a cavity in a conductor, the electric field is zero.
Reason (R): Charges in a conductor reside only at its surface.

47. **Assertion (A):** An electric field produces the same acceleration in electron and proton.
Reason (R): For a given force, acceleration does not depend upon mass.

48. **Assertion (A):** When the electric flux through a closed surface is zero then the net charge inside the surfacemust be zero.
Reason (R): When the net charge inside a closed surface is zero then electric field at every point of the Gaussian surface must be zero.

49. **Assertion (A):** In a non-uniform electric field, a dipole will have translatory as well as rotatory motion.
Reason (R): In non-uniform electric field a dipole experiences force as well as torque.

50. **Assertion (A):** Electric lines of force never cross each other.
Reason (R): Electric field at a point superimposes to give one resultant electric field.

51. **Assertion (A):** No work is done in moving a test chargefrom one point to another over an equipotential surface
Reason (R): Electric field is always normal to the equipotential surface at every point.

52. **Assertion (A):** A metal plate is introduced between the plates of a charged parallel plate capacitor, its capacitance increased.
Reason (R): A metal plate is introduced between the plates of a charged parallel plate capacitor, the effective separation between the plates is decreased.

53. **Assertion (A):** Polar molecules have permanent dipolemoment.
Reason (R): In polar molecules, the centres of positive and negative charges coincide even when there is no external field.

54. **Assertion (A):**Work done by the electrostatic force inbringing the unit positive charge from infinity to the point P is positive.
Reason (R): The force on a unit positive test charge is attractive, so that the electrostatic force and the displacement (from infinity to P) are in the same direction.

55. Assertion (A): Work done in moving a charge between any two points in an electric field is independent of the path followed by the charge, between these points.
Reason (R): Electrostatic force is a non conservative force.

CASE BASED QUESTIONS:

56. Gauss's Law and Coulomb's law although expressed in different forms, are equivalent ways of describing the relations between charge and electric field in static conditions. Gauss's law is $\Phi = q_{encl}/\varepsilon_o$, when q_{encl} is the net charge inside an imaginary closed surface called Gaussian Surface. $\Phi = \oint \vec{E}.\overrightarrow{ds}$ gives electric flux through the Gaussian surface. The two equations hold only when the net charge is in vacuum or air.

i) If there is only one type of charge in the universe, then (E- Electric field, ds- area vector)

a) $\oint \vec{E}.\overrightarrow{ds}$ is not zero on any surface
b) $\oint \vec{E}.\overrightarrow{ds}$ could not be defined
c) $\oint \vec{E}.\overrightarrow{ds}$ equals infinity if charge is inside
d) $\oint \vec{E}.\overrightarrow{ds}$ = 0 if charge is outside, $\oint \vec{E}.\overrightarrow{ds}$= q/ ε_o if charge isinside

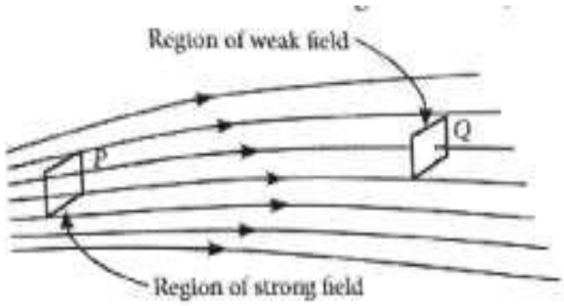
(ii) What is the nature of Gaussian surface involved in the Gauss's law of electrostatics?
a) Magnetic b) Scalar c) Vector d) Electrical

(iii)The electric flux through a closed surface area S enclosing charge Q is Φ. If surface area is doubled then the electric flux is
a) 2 Φ b) Φ/2 c) Φ /4 d) Φ

(iv) A Gaussian Surface encloses a dipo le. The electric fluxthrough this surface is

a) q / ε_0 b) $2q/ \varepsilon_0$ c) $q/2 \varepsilon_0$ d) zero

57) Electric field strength is proportional to the density of lines of force i.e. electric field strength at a point is proportional to the number of lines of force cutting a unit area element placed normal to the field at that point. As illustrated in the given fig. the electric field at point P is stronger than at Q.



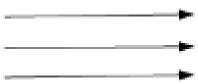
Electric lines of force about a positive point charge are

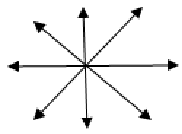
a) radially outwards b) circular clockwise
c) radially inwards d) parallel straight line

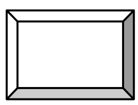
ii) Which one of the following is false for electric lines offorce

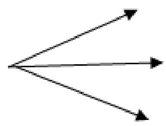
a) they always start from positive charges & terminate onnegative charges
b) they are always perpendicular to the surface of a chargedconductor
c) they always form closed loops
d) they are parallel & equally spaced in a region of uniformelectric field

iii) Which one of the following pattern of electric lines offorce is not possible in field due to stationary charges

a) 

b) 





c) d)

iv) Electric lines of force are curved

a) in the field of a single positive or negative charge
b) in the field of a two equal & opposite charges
c) in the field of a two like charges
d) both (b) & (c)

58) When electric dipole is placed in uniform electric field, its two charges experience equal opposite forces, which cancel each other & hence net force on electric dipole in uniform electric field is zero. However these forces are not collinear so they give rise to some torque on the dipole.

Since net force on electric dipole in uniform electric field is zero, so no work is done in moving the electric dipole in uniform electric field. However some work is done in rotating the dipole against the torque acting on it.

i) The dipole moment of a dipole in a uniform external field E is p. Then the torque τ acting on the dipole is

a) $\tau = pE \sin\theta$ b) $\tau = pE \cos\theta$
c) $\tau = 2pE \sin\theta$ d) $\tau = p + E$

ii) An electric dipole consists of two opposite charges each of magnitude 1.0 μC separated by a distance of 2.0 cm. The dipole is placed in an external field of 10^5 NC^{-1}. The maximum torque on the dipole is

a) 0.2×10^{-3} Nm b) 1×10^{-3} Nm
c) 2×10^{-3} Nm d) 4×10^{-3} Nm

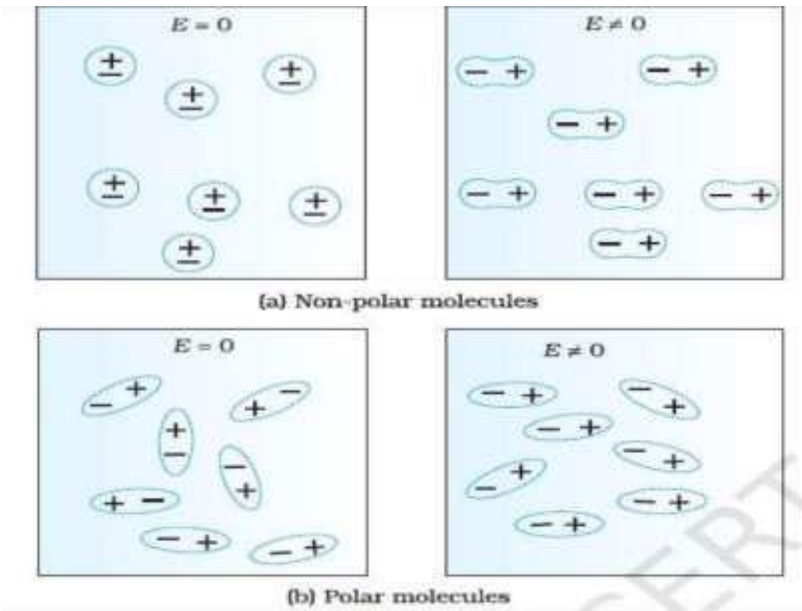
iii) Torque on a dipole in uniform electric field is minimum when ɵ is equal to

a) 0˚ b) 90˚ c) 180˚ d) both a) & c)

iv) When an electric dipole is held at an angle in a uniformelectric field, the net force F & torque τ on the dipole are

a) F=0, τ =0 b) F≠ 0, τ ≠ 0 c) F=0, τ ≠ 0 d) F≠ 0, τ= 0

59. Dielectric with polar molecules also develops a net dipole moment in an external field, but for a different reason. In the absence of any external field, the different permanent dipoles are oriented randomly due to thermal agitation; so the total dipole moment is zero. When an external field is applied, the individual dipole moments tend to align with the field. When summed overall the molecules, there is then a net dipole moment in the direction of the external field, i.e., the dielectric is polarized. The extent of polarization depends on the relative strength of two factors: the dipole potential energy in the external field tending to align the dipoles mutually opposite with the field and thermal energy tending to disrupt the alignment. There may be, in addition, induced dipole moment‘ effect as for non-polar molecules, but generally the alignment effect is more important for polar molecules. Thus in either case, whether polar or non- polar, a dielectric develops a net dipole moment in the presence of an external field. The dipole moment per unit volume is called polarization.



(i) The best definition of polarization is

(a) Orientation of dipoles in random direction
(b) Electric dipole moment per unit volume
(c) Orientation of dipole moments
(d) Change in polarity of every dipole

(ii) Calculate the polarization vector of the material which has 100 dipoles per unit volume in volume of 2 units.

(a) 200 (b) 50 (c) 0.02 (d) 100

(iii) The total polarization of a material is the

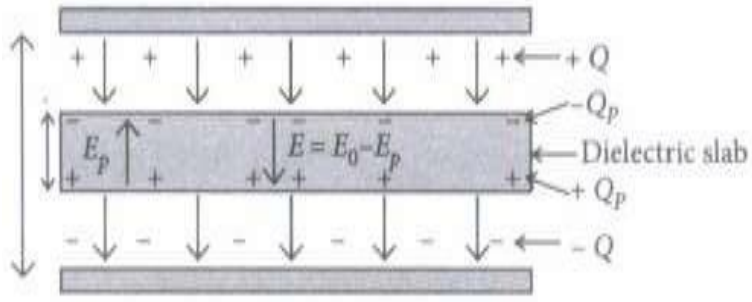
(a) Product of all types of polarization (b) Sum of all types of polarization

(c) Orientation directions of the dipoles (d) Total dipole moments in the material

(iv) Dipoles are created when dielectric is placed in

(a) Magnetic Field (b) Electric field (c) Vacuum (d) Inert environment

60. A dielectric slab is a substance which does not allow the flow of charges through it but permits them to exert electrostatic forces on one another. When a dielectric slab is placed between the plates, the field E_o polarizes the dielectric. This induces charge -Qp on the upper surface and + Qp on the lower surface of the dielectric. These induced charges set up a field Ep inside the dielectric in the opposite direction of E_o as shown.



(i) In a parallel plate capacitor, the capacitance increases from 4μF to 80μF on introducing a dielectric medium between the plates. What is the dielectric constant of the media?

(a) 10 (b) 20 (c) 50 (d) 100

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

(a) 8pF (b) 10pF (c) 80pF (d) 100pF

(iii) A dielectric introduced between the plates of a parallel plate condenser

(a) decreases the electric field between the plates

(b) increases the capacity of the condenser

(c) increases the charge stored in the condenser

(d) increases the capacity of the condenser

(iv) A parallel plate capacitor of capacitance 1 pF has separation between the plates is d. When the distance of separation becomes 2d and wax of dielectric constant x is inserted in it the capacitance becomes 2 pF. What is the value of x?

(a) 2 (b) 4 (c) 6 (d) 8

UNIT-I: ELECTROSTATICS (KEY for MCQs)

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
c	d	a	c	a	b	b	a	c	c
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
b	c	c	b	a	b	a	b	c	d
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
b	b	c	c	a	b	c	b	a	d
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
d	d	b	d	b	a	d	d	b	b

41	42	43	44	45	46	47	48	49	50
b	c	c	d	a	a	d	c	a	b
51	52	53	54	55					
b	a	c	a	c					
56	i	ii	iii	iv	57	i	ii	iii	iv
	d	c	d	d		a	c	c	d
58	i	ii	iii	iv	59	i	ii	iii	iv
	a	c	d	c		b	a	b	b
60	i	ii	iii	iv					
	b	c	a	b					

SOLUTIONS (ELECTROSTATICS)

1. (c) By Q =Ne or $N=\frac{Q}{e}\therefore N=\frac{80\times10^{-6}}{1.6\times10^{-19}}=5\times10^{14}$

2. (d) Resultant charges after adding the – 2*C* be $(-2+2)=0$ and $(-2+6)=+4C$

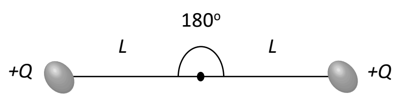
$$\Rightarrow F=\frac{k\,Q_1Q_2}{r^2}=k\times\frac{0\times4}{r^2}=0$$

3. (a) Let separation between two parts be $r \Rightarrow F=k.q\frac{(Q-q)}{r^2}$

For *F* to be maximum $\frac{dF}{dq}=0\Rightarrow\frac{Q}{q}=\frac{2}{1}$

4. (c) We put a unit positive charge at *O*. Resultant force due to the charge placed at *A* and *C* is zero and resultant charge due to *B* and *D* is towards *D* along the diagonal *BD*.

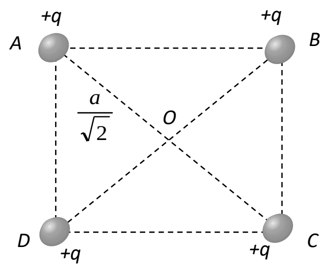
5. (a) The position of the balls in the satellite will become as shown below



Thus angle θ= 180° and Force $=\frac{1}{4\pi\varepsilon_0}\cdot\frac{Q^2}{(2L)^2}$

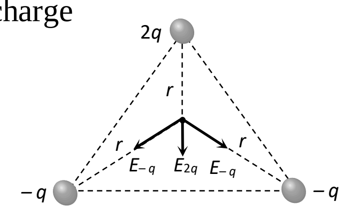
6. (b) Potential at the centre *O*, $V=4\times\frac{1}{4\pi\varepsilon_0}\cdot\frac{Q}{a/\sqrt{2}}$

where $Q=\frac{10}{3}\times10^{-9}C$ and $a=8\,cm=8\times10^{-2}\,m$



So $V = 5\times 9\times 10^9 \times \dfrac{\frac{10}{3}\times 10^{-9}}{\frac{8\times 10^{-2}}{\sqrt{2}}} = 1500\sqrt{2}\, volt$

7. (b) Obviously, from charge configuration, at the centre electric field is non-zero. Potential at the centre due to $2q$ charge and potential due to $-q$ charge

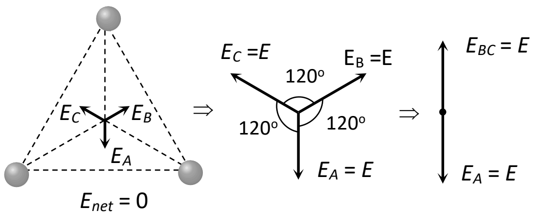


$V_{-q} = -\dfrac{q}{r}$ (r = distance of centre point)

$\therefore$ Total potential $V = V_{2q} + V_{-q} + V_{-q} = 0$

8. (a) In non-uniform electric field. Intensity is more, where the lines are more denser.

9. (c)



10. (c) ABCDE is an equipotential surface, on equipotential surface no work is done in shifting a charge from one place to another.

11. (b) According to the question, $eE = mg \Rightarrow E = \dfrac{mg}{e}$

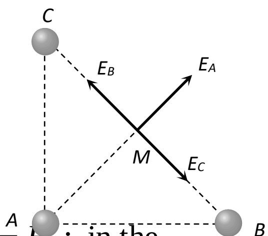
12. (c) $a = \dfrac{qE}{m} \Rightarrow \dfrac{a_e}{a_p} = \dfrac{m_p}{m_e}$

13. (c) $W = U_f - U_i = 9\times 10^9 \times Q_1 Q_2 \left[\dfrac{1}{r_2} - \dfrac{1}{r_1}\right]$

$\Rightarrow W = 9\times 10^9 \times 12\times 10^{-6} \times 8\times 10^{-6}\left[\dfrac{1}{4\times 10^{-2}} - \dfrac{1}{10\times 10^{-2}}\right]$

= 12.96 $J \approx$ 13 J

14. (b) E_A = Electric field at M due to charge placed at A
E_B = Electric field at M due to charge placed at B
E_C = Electric field at M due to charge placed at C



As seen from figure $|\overrightarrow{E_B}| = |\overrightarrow{E_C}|$, so net electric field at $M, E_{net} = E_A$; in the direction of vector 2.

15. (a) By using $W = Q(\vec{E}.\Delta\vec{r})$
$\Rightarrow W = Q[(e_1\hat{i} + e_2\hat{j} + e_3\hat{k}).(a\hat{i} + b\hat{j})] = Q(e_1 a + e_2 b)$

16. (b) By using $V = 9\times 10^9 \times \dfrac{Q}{r} = 9\times 10^9 \times \dfrac{100\times 10^{-6}}{9} = 10^5 V$

17. (a) By using $QE = mg$
$\Rightarrow E = \dfrac{mg}{Q} = \dfrac{10^{-6}\times 10}{10^{-6}} = 10 V/m$; upward because charge is positive.

18. (b) When a negatively charged pendulum oscillates over a positively charged plate then effective value of g increases so according to $T = 2\pi\sqrt{\frac{l}{g}}$, T decreases.

19. (c) When charge q is released in uniform electric field E then its acceleration $a = \frac{qE}{m}$ (is constant). So its motion will be uniformly accelerated motion and its velocity after time t is given by $v = at = \frac{qE}{m}t$

$$\Rightarrow KE = \frac{1}{2}mv^2 = \frac{1}{2}\left(\frac{qE}{m}t\right)^2 = \frac{q^2E^2t^2}{2m}$$

20. (d) Conducting surface behaves as equipotential surface.

21. (b) In the direction of electric field potential decreases.

22. (b) Relation for electric field is given by $E = \frac{\lambda}{2\pi\varepsilon_0 r}$

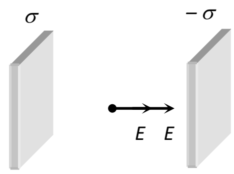
(Given : $E = 7.182 \times 10^8 N/C$) $r = 2\ cm = 2 \times 10^{-2} m$

$$\frac{1}{4\pi\varepsilon_0} = 9\times10^{-9} \Rightarrow \lambda = 2\pi\varepsilon_0 rE = \frac{2\times2\pi\varepsilon_0 rE}{2} = \frac{1\times2\times10^{-2}\times7.182\times10^8}{2\times9\times10^9} = 7.98\times10^{-4} C/m$$

23. (c) Electric field between the plates is

$$= \frac{\sigma}{2\varepsilon_0} - \frac{(-\sigma)}{2\varepsilon_0}$$

$$= \frac{\sigma}{\varepsilon_0}\ volt/meter$$



24. (c) Electric field outside of the sphere $E_{out} = \frac{kQ}{r^2}$ ...(i)

Electric field inside the dielectric sphere $E_{in} = \frac{kQx}{R^3}$ ...(ii)

From (i) and (ii), $E_{in} = E_{out} \times \frac{r^2 x}{R}$

$\Rightarrow$ At 3 cm, $E = 100 \times \frac{3(20)^2}{10^3} = 120 V/m$

25. (a) As the dipole will feel two forces which are although opposite but not equal.
$\therefore$ A net force will be there and as these forces act at different points of a body.
A torque is also there.

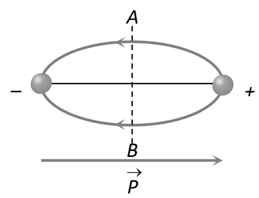
26. (b) Maximum torque = $pE = 2 \times 10^{-6} \times 3 \times 10^{-2} \times 2 \times 10^5 = 12 \times 10^{-3} N\text{-}m$.

27. (c) Torque on a dipole = PE sinθ

4 =q l E sin30^0 = q x 2 x10-2x 2x105 x1/2

q =2 x10^{-3} = 2 mC

28. (b) The direction of electric field at equatorial point A or B will be in opposite direction, as that of direction of dipole moment.

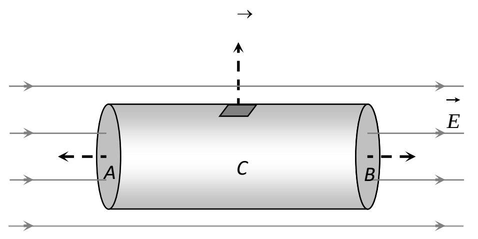


29. (a)

30. (d) $V = \frac{p\cos\theta}{r^2}$ If $\theta = 0°$ then $V_a = \max$.

If $\theta = 180°$ then $V_e = \min$.

31. (d) Flux through surface $A\ \phi_A = E \times \pi R^2$ and $\phi_B = -E \times \pi R^2$



Flux through curved surface $C = \int \vec{E}.\vec{ds} = \int E\, ds \cos 90^o = 0$

$\therefore$ Total flux through cylinder $= \phi_A + \phi_B + \phi_C = 0$

32. (d) $\phi = \frac{\Sigma q}{\varepsilon_0} = 0$ *i.e.* net charge on dipole is zero.

33. (b) Charge enclosed by cylindrical surface (length 100 *cm*) is $Q_{enc} = 100Q$.

By applying Gauss's law $\phi = \frac{1}{\varepsilon_0}(Q_{enc.}) = \frac{1}{\varepsilon_0}(100Q)$

34. (d) By Gauss's law $\phi = \frac{1}{\varepsilon_0}$ $(Q_{enclosed})$

$\Rightarrow Q_{enclosed} = \phi\varepsilon_0 = (-8\times10^3 + 4\times10^3)\varepsilon_0 = -4\times10^3\,\varepsilon_0\, Coulomb.$

35. (b) $\phi = \frac{1}{\varepsilon_0} \times Q_{enc} = \frac{1}{\varepsilon_0}(2q)$

36. (a) Flux is due to charges enclosed per ε_0

$\therefore$ Total flux = $(-14 + 78.85 - 56)nC/\varepsilon_0 = 8.85\times10^{-9}C \times \frac{4\pi}{4\pi\varepsilon_0} = 8.85\times10^{-9}\times9\times10^9\times4\pi$

$= 1000.4\,Nm^2/C$ *i..e.* $1000\ Nm^2C^{-1}$

37. (d) $C_{medium} = K\,C_{air} \Rightarrow K = \frac{C_{medium}}{C_{air}} = \frac{110}{50} = 2.20$

38. (d) $C = \frac{K\varepsilon_0 A}{d}$

39. (b) $E = \frac{V}{d} = \frac{100}{10^{-3}} = 10{,}0000\,V/m$

40. (b) $U = \frac{Q^2}{2C} = \frac{(40\times10^{-6})^2}{2\times10^{-6}\times10} = \frac{16\times10^{-10}}{2\times10^{-5}} = 8\times10^{-5}\,J$

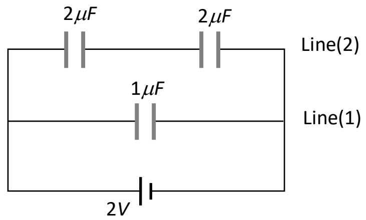
41. (b) $F = \frac{CV^2}{2d} = \frac{Q\times E}{2} = \frac{10^{-6}\times10^5}{2} = 0.05N$

42. (c) $C_{eq} = \frac{C_1C_2}{C_1+C_2} = 2.4\mu F.$ Charge flown = $2.4 \times 500 \times 10^{-6}C = 1200\ \mu C.$

43. (c) $V = \frac{V_1C_1 + V_2C_2}{C_1+C_2} = \frac{500\times20 + 200\times10}{20+10} = 400V$

44. (d) Potential difference across both the lines is same i.e. 2 V. Hence charge flowing in line 2

$Q = \left(\frac{2}{2}\right) \times 2 = 2\,\mu C$ So charge on each capacitor in line (2) is 2 μC



45. (a) In series $C' = C/n$ $i.e.$ $C = nC' = 2 \times 3 = 6\,\mu F$

In parallel $C' = nC$ $i.e.$ $C = \frac{C'}{n} = \frac{12}{2} = 6\,\mu F$

$C = nC' = 2 \times 3 = 6\,\mu F$

In parallel $C' = nC$ $i.e.$ $C = \frac{C'}{n} = \frac{12}{2} = 6\,\mu F$

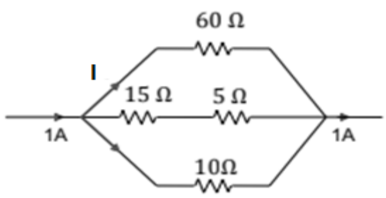
Unit-II: CURRENT ELECTRICITY

MCQs (Chapter-3)

1. Radha while playing with a resistance wire of 6Ω, cuts the wire into three equal parts. The maximum value of resistance she can obtain by connecting them in any manner she choose, being free to use any number of the wire pieces available with her
   a) 3Ω b) 4Ω c) 6Ω d) 5Ω

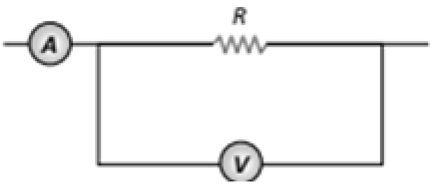
2. Three resistors R_1, R_2 and R_3 ($R_1>R_2>R_3$) are connected in series. If current I_1, I_2 and I_3 respectively is flowing through them, the correct relation will be
   a) $I_1 = I_2 = I_3$ c) $I_1 > I_2 > I_3$
   b) $I_1 < I_2 < I_3$ d) $I_1 > I_2 < I_3$

3. The magnitude of I in ampere is



   a) 0.1
   b) 0.3
   c) 0.6
   d) None of these

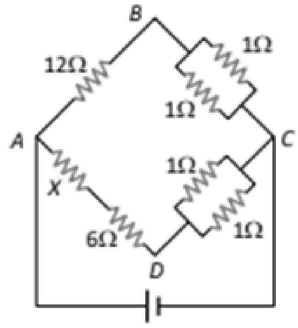
4. The ammeter A reads 2A and a voltmeter reads 20V. The value of resistance R is



   a) 10Ω
   b) Less than 10Ω
   c) More than 10Ω
   d) Can't be decided

5. Current provided by a battery is maximum when
   a) Internal resistance equal to external resistance
   b) Internal resistance is greater than external resistance
   c) Internal resistance is less than external resistance
   d) None of these.

6. For what value of unknown resistance X, the potential difference between B and D will be zero in the circuit shown in the figure



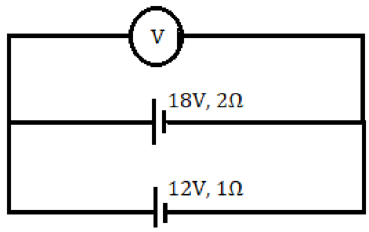
   a) 4Ω
   b) 6Ω
   c) 2Ω
   d) 5Ω

7. A cell of internal resistance r is connected across an external resistance R can supply maximum current when
   a) R=r b) R>r c) R=r/2 d) R=0

8. In a Wheatstone's bridge, all four arms have equal resistance R. If the resistance of the galvanometer arm is also R, the equivalent resistance of the combination as seen by the battery is
   a) R b) 2R c) R/2 d) R/4

9. In a current carrying conductor, the ratio of the electric field and current density at a point is called
   a) Resistivity b) Conductivity c) Resistance d) Mobility

10. Two batteries, one of emf 18V and internal resistance 2Ω and other of emf 12V and internal resistance 1Ω, are connected as shown. The voltmeter V will record a reading of

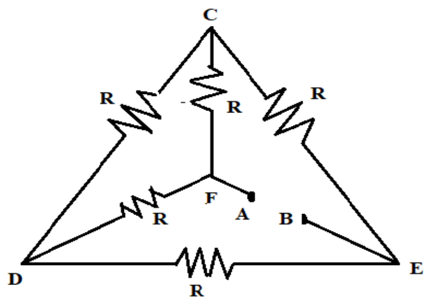


   a) 30V b) 18V
   c) 15V d) 14V

11. Three resistances P, Q, R each of resistance 2Ω and an unknown resistance S form the four arms of a Wheatstone bridge circuit. When a resistance of 6Ω is connected in parallel to S, the bridge gets balanced. What is the value of S?
   a) 2Ω b) 3Ω c) 6Ω d) 1Ω

12. An unknown resistance R_1 is connected in series with resistance of 10Ω. This combination is connected to one gap of a meter bridge, while other gap is connected to another resistance R_2. The balance point is at 50cm. Now when the 10Ω resistance is removed, the balance point shifts to 40cm. Then the value of R_1 (in Ω) is
   a) 60 b) 40 c) 20 d) 10

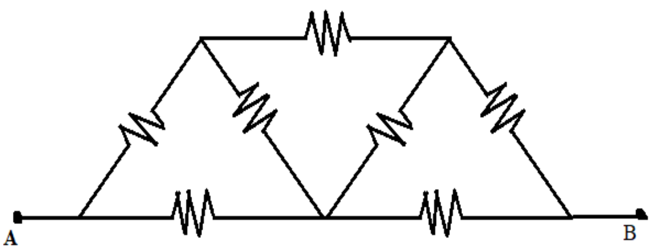
13. Each of the resistances in the network shown in the figure is equal to R. The resistance between the terminals A and B is



   a) R
   b) 5R
   c) 3R
   d) 6R

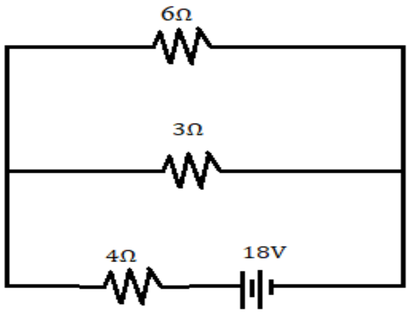
14. A 6V battery is connected to the terminals of a three meter long wire of uniform thickness and resistance of 100Ω. The difference of potential between two points on the wire separated by a distance of 50cm will be
   a) 2V b) 3V c) 1V d) 1.5V

15. In the network shown in the figure, each resistance is 1Ω. The effective resistance between the points A and B is
   a) $\frac{4}{3}\Omega$
   b) $\frac{3}{2}\Omega$
   c) 7Ω
   d) $\frac{8}{7}\Omega$



16. A filament bulb (500W, 100V) is to be used in a 230V main supply. When a resistance R is connected in series, it works perfectly and the bulb consumes 500W. The value of R is
    a) 26Ω b) 13Ω c) 230Ω d) 46Ω

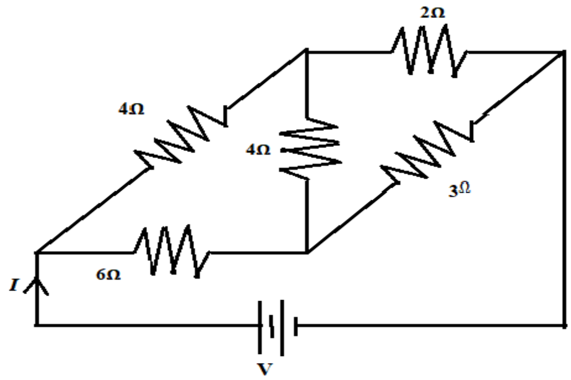
17. The total power dissipated in watts in the circuit shown here is
    a) 16
    b) 40
    c) 54
    d) 4



18. When three identical bulbs of 60 watt-200 volt rating are connected in series to a 200V supply, the power drawn by them will be
    a) 60 watt b) 180 watt c) 10 watt d) 20 watt

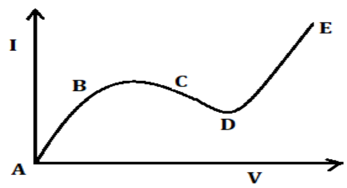
19. Two wires of the same metal have same length, but their cross-section is in the ratio 3:1. They are joined in series. The resistance of thicker wire is 10Ω. The total resistance of the combination will be
    a) $\frac{5}{2}\Omega$ c) $\frac{40}{3}\Omega$
    b) 40Ω d) 100Ω

20. For the network shown in figure, the value of current I is
    a) $\frac{9}{35}V$ c) $\frac{18}{5}V$
    b) $\frac{5}{9}V$ d) $\frac{5}{18}V$

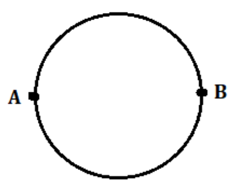


21. Three copper wires have lengths and cross-sectional area as (l, A); (2l, A/2) and (l/2,2A). Resistance is minimum in
    a) Wire of cross-sectional area A/2 c) Wire of cross-sectional area A
    b) Wire of cross-sectional area 2A d) Same in all three case

22. From the graph between current (I) and voltage (V) as shown in the figure, identify the portion corresponding to negative resistance.
    a) AB c) BC
    b) CD d) DE



23. A wire of resistance 12Ω per meter is bent to form a complete circle of radius 10cm. The resistance between its two diametrically opposite points, A and B as shown in the figure is
    a) 3Ω c) 6π Ω
    b) 6Ω d) 0.6π Ω
    c)

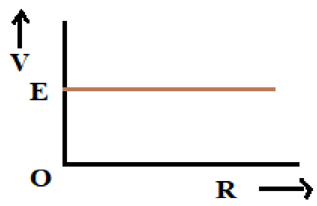


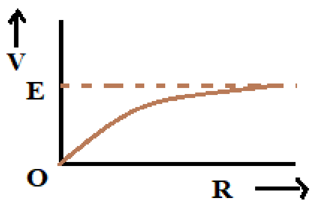
24. In the series combination of two or more than two resistances
    (a) the current through each resistance is same.
    (b) the voltage through each resistance is same.
    (c) neither current nor voltage through each resistance is same.
    (d) both current and voltage through each resistance are same.

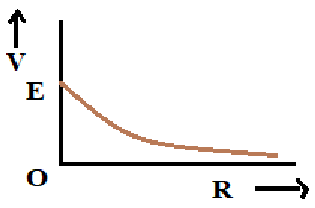
25. In a balanced Wheatstone bridge if the battery and galvanometer are interchanged then the deflection in galvanometer will
    (a) change in previous direction   (b) not change
    (c) change in opposite direction   (d) none of these.

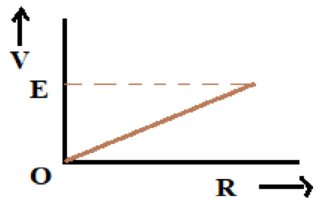
26. When no current is passed through a conductor,
    (a) the free electrons do not move
    (b) the average speed of a free electron over a large period of time is not zero
    (c) the average velocity of a free electron over a large period of time is zero
    (d) the average of the velocities of all the free electrons at an instant is zero

27. A cell of emf (E) and internal resistance r is connected across a variable external resistance R. The graph of terminal potential difference V as a function of R is

(a)


(b)


(c)


(d)


ASSERTION - REASON TYPE QUESTIONS:

Two statements are given –one labelled Assertion (A) and other labelled Reason (R). Select the correct answer to these questions from the options as given below.
a) If both Assertion and Reason are true and Reason is correct explanation of Assertion.
b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
c) If Assertion is true but Reason is false.
d) If both Assertion and Reason are false

28. **Assertion**: A wire carrying an electric current has no electric field around it
    Reason: Rate of flow of electrons in one direction is equal to rate of flow of protons in opposite direction.
29. **Assertion**: The value of temperature coefficient of resistance is positive for metals.
    Reason: The temperature coefficient of resistance for insulator is also positive.

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

31. **Assertion:** Voltmeter is connected in parallel with the circuit.
Reason : Resistance of a voltmeter is very large.

32. **Assertion**: The dimensional formula for product of resistance and conductance is same as for dielectric constant.
Reason: Both have dimensions of time.

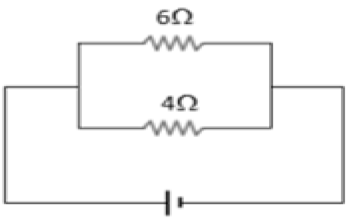
CASE BASED QUESTIONS

33. **Electric power** is the rate at which electrical energy is transferred by an electric circuit. The SI unit of power is the watt, one joule per second. A common misconception is that electric power is bought and sold, but actually electrical energy is bought and sold. For example, electricity sold to consumers is measured in terms of amounts of energy, kilowatt-hours (kilowatts multiplied by hours), and not the rate at which this energy is transferred.
Electric power is usually produced by electric generators, but can also be supplied by sources such as electric batteries. It is usually supplied to businesses and homes (as domestic mains electricity) by the electric power industry through an electrical grid.

$$\wp = IV = I^2R = \frac{V^2}{R}$$

(i) A wire when connected to 220V mains supply has power dissipation P_1. Now the wire is cut into two equal pieces which are connected in parallel to the same supply. Power dissipation in this case is P_2. Then $P_2:P_1$ is
a) 1 b) 4 c) 2 d) 3

(ii) In the circuit shown, the power developed in the 6Ω resistor is 6watt. The power in watts developed in the 4Ω resistor is



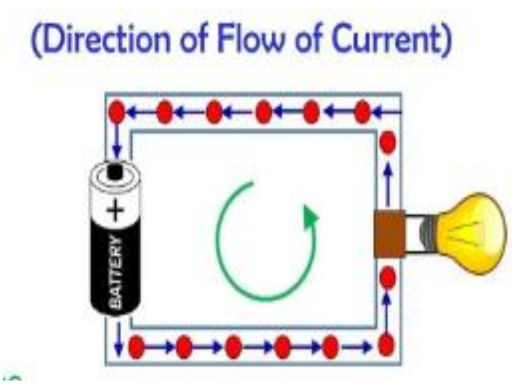
a) 16
b) 9
c) 6
d) 4

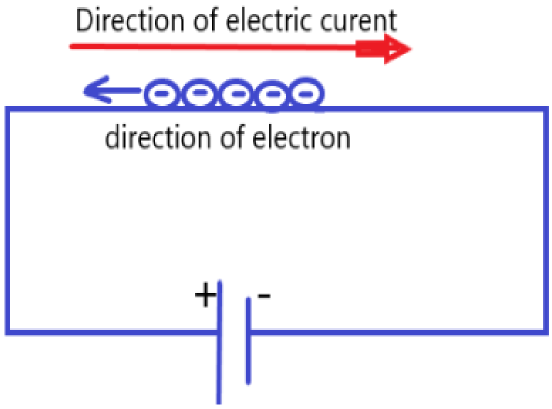
(iii) Two wires A and B of the same material and having same length, have their cross-sectional area in the ratio 1:6. What would be the ratio of heat produced in these wires when same voltage is applied across each?
a) 6:1 b) 1:6 c) 3:4 d) 4:3

(iv) If two wires having resistance R and 2R both are joined in series and in parallel, then ratio of heat generated in this situation, applying the same voltage is
a) 2:1 b) 1:2 c) 2:9 d)9:2

(v) The element of a heater is rated (P,V). If it is connected across a source of voltage V/2, then the power communed by it will be
a) P b) 2P c) P/2 d) P/4

34. The direction of an electric current is by convention the direction in which a positive charge would move. Thus, the current in the external circuit is directed away from the positive terminal and toward the negative terminal of the battery. In other words direction of current is opposite to the motion of negative charge or electrons.

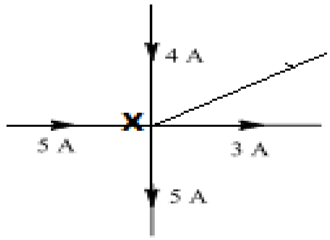




In a close circuit, the algebraic sum of currents at a junction is zero. It is followed by Kirchhoff's current law which states that "at any junction, the sum of currents entering the junction is equal to the sum of currents leaving the junction."

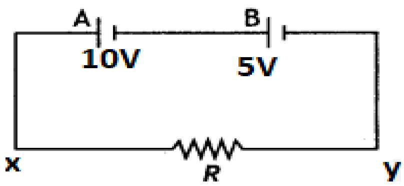
(i) Five conductors are meeting at a point x as shown in the figure. What is the value of current in fifth conductor?

a) 3A away from x
b) 1A away from x
c) 4A away from x
d) 1A towards x



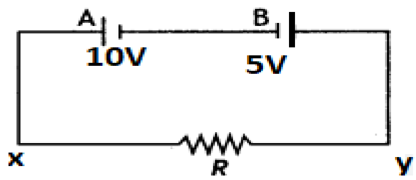
(ii) In the given circuit what is the direction of current across resistor R

a) X to Y
b) Y to X
c) Zero current
d) none of these



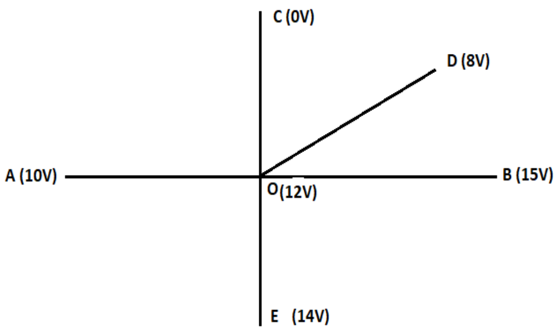
(iii) In the given circuit what is the direction of current across resistor R

a) X to Y
b) Y to X
c) Zero current
d) none of these



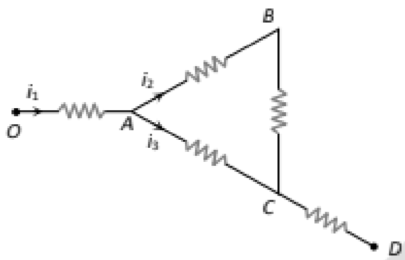
(iv) In the given set up of resistance wire what is direction of current in branches OE , OD and AO

a) O to E, O to D and A to O
b) E to O, O to D and O to A
c) E to O, D to O and A to O
d) E to O, O to D and A to O

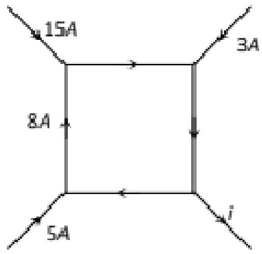


(v) The current in the arm CD of the circuit will be

a) $i_1 + i_2$
b) $i_2 + i_3$
c) $i_1 + i_3$
d) $i_1 - i_2 + i_3$



(vi) The figure shows a network of currents. What is value of i?



a) 3A
b) 13A
c) 23A
d) -3A

35. Resistivity, commonly symbolized by the Greek letter rho, ρ, is quantitatively equal to the resistance *R* of a specimen such as a wire, multiplied by its cross-sectional area *A*, and divided by its length *l*; $\rho = RA/l$. The unit of resistance is the ohm. In the metre-kilogram-second (MKS) system, the ratio of area in square metres to length in metres simplifies to just metres. Thus, in the metre-kilogram-second system, the unit of resistivity is ohm-metre. If lengths are measured in centimetres, resistivity may be expressed in units of ohm-centimetre.
The resistance of a wire is directly proportional to its length and inversely proportional to its cross-sectional area. Resistance also depends on the material of the conductor. See resistivity. The resistance of a conductor, or circuit element, generally increases with increasing temperature.
Resistance**,** in electricity, is a property of an electric circuit or part of a circuit that transforms electric energy into heat energy in opposing electric current. Resistance involves collisions of the current-carrying charged particles with fixed particles that make up the structure of the conductors. Resistance is often considered as localized in such devices as lamps, heaters, and resistors, in which it predominates, although it is characteristic of every part of a circuit, including connecting wires and electric transmission lines.
The dissipation of electric energy in the form of heat, even though small, affects the amount of electromotive force, or driving voltage, required to produce a given current through the circuit. In fact, the electromotive force *V* (measured in volts) across a circuit divided by the current *I* (amperes) through that circuit defines quantitatively the amount of electrical resistance *R*. Precisely, $R = V/I$. Thus, if a 12V battery steadily drives a two-ampere current through a length of wire, the wire has a resistance of six volt per ampere, or six ohm. The ohm is the common unit of electrical resistance, equivalent to one volt per ampere and represented by the capital Greek letter omega, Ω. The resistance of a wire is directly proportional to its length and inversely proportional to its cross-sectional area. Resistance also depends on the material of the conductor.

(i) An electric wire of length ‘L’ and area of cross-section A has resistance R ohm. Another wire of the same material having same length and area of cross-section 4A has resistance of
a) 4R b) R/4 c) R/16 d) 16R

(ii) A resistance of 2Ω is to be made from copper wire (specific resistance $=1.7\times10^{-8}\Omega$m) using a wire of length 50cm. The radius of the wire is
a) 0.0116mm b) 0.0367mm c) 0.116mm d) 0.267mm

(iii) The resistance of straight conductor does not depend upon its
a) Temperature b) length c) material d) potential difference

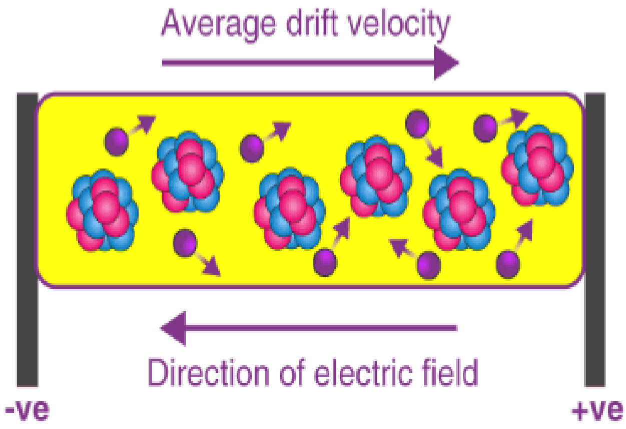
(iv) A certain wire has resistance R. The resistance of another wire identical with the first except having twice its diameter is
a) 2R b) 0.25R c) 4R d) 0.5R

(v) Two wires A and B of the same material, having radii in the ratio 1:2 and carrying current in the ratio 4:1. The ratio of drift speed of electrons in A and B
a) 16:1 b) 1:16 c) 1:4 d) 4:1

(vi) The electric resistance of a certain wire of iron is R if its length and radius are both doubled then

a) The resistance and the specific resistance will both remain unchanged.
b) The resistance will be doubled, the specific resistance will be halved.
c) The resistance will be halved, the specific resistance will remain unchanged.
d) The resistance will be halved, the specific resistance will be doubled.

36. Drift velocity: Drift velocity is the average velocity with which electrons 'drift' in the presence of an electric field. It's the drift velocity (or drift speed) that contributes to the electric current. In contrast, thermal velocity causes random motion resulting in collisions with metal ions.



Every material above absolute zero temperature which can conduct like metals will have some free electrons moving at random velocity. When a potential is applied around a conductor the electrons will tend to move towards the positive potential, but as they move, they will collide with atoms and will bounce back or lose some of their kinetic energy. However, due to the electric field, the electrons will accelerate back again, and these random collisions will keep happening but as the acceleration is always in the same direction due to the electric field, the net velocity of the electrons will also be in the same direction.

$a = \frac{F}{m} = \frac{-\mu E}{m}$

$u = v + at$

Here,

v = 0

t = T (relaxation time that is the time required by an electron to return to its initial equilibrium value)

$u = aT$

(substituting for v and u)

$\therefore u = (\frac{-\mu E}{m})T$

(substituting for a)

This is the final equation explaining drift velocity.

But as the temperature increases, the drift velocity of electrons increases in a metallic conductor.

(i) Drift velocity of a free electron inside a conductor is
a) The thermal speed of the free electron
b) The speed with which a free electron emerges out of the conductor
c) The average speed required by the electron in any direction
d) The average speed of the electron between successive collisions in the direct opposite to the applied electric field.

(ii) A metal wire is subjected to a constant potential difference. When the temperature of the metal wire increases, the drift velocity of the electron in it
a) Increases, thermal velocity of electron increases
b) Decreases, thermal velocity of electron increases
c) Increases, thermal velocity of electron decreases.
d) Decreases, thermal velocity of electron decreases.

(iii) A potential difference V is applied to a copper wire. If the potential difference is increased to 2V, then the drift velocity of electrons will

a) be doubled the initial velocity b) remain same
c) be $\sqrt{2}$ times the initial velocity d) be half the initial velocity

(iv) The relaxation time in conductors
a) increases with increase in temperature
b) decreases with increase in temperature
c) it does not depend on temperature
d) all of sudden changes at 400 Kelvin

(v) Which of the following characteristic of electrons determines the current in a conductor?
a) Drift velocity alone b) Thermal velocity alone
c) Both drift and thermal velocity d) Neither drift nor thermal velocity

(vi) When the length and area of cross-section both are doubled, then drift velocity
a) Will become half c) will be doubled
b) Will remain the same d) will become four times

(vii) When a current I is setup in a wire of radius r, the drift velocity is v_d. If the same current is set up through a wire of radius 2r, the drift velocity will be
a) $4v_d$ b) $2v_d$ c) $v_d/2$ d) $v_d/4$

(viii) When no current is passed through a conductor
a) The free electron 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 zero

37. INTERNAL RESISTANCE OF CELL: Cells, EMF, Internal Resistance (r) are the components which complete the circuit and help the flow of electricity within the circuit. Cells, emf and internal resistance are inter-related to one another. Batteries i.e. Cells are posses internal resistance and potential difference i.e. voltage (V). Internal resistance is the resistance within a battery, or other voltage sources that causes a drop in the source voltage when there is a current. A cell can be thought of as a source of e.m.f. (ε) with a resistor connected in series. When current flows through the cell a voltage develops across the internal resistance.
$V = \varepsilon - Ir$

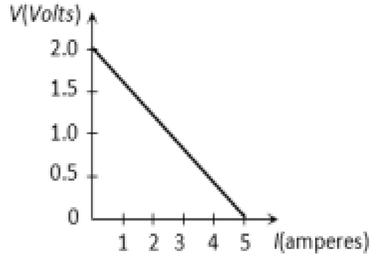
(i) The terminal voltage of a cell in an open circuit condition is
a) Less than its emf c) More than its emf
b) Equal to its emf d) Depends on its internal resistance

(ii) What is the p.d. across the terminals (V_T) of a cell with emf ε for the open circuit?
a) $V_T < \varepsilon$ b) $V_T > \varepsilon$ c) $V_T = 0$ d) $V_T = \varepsilon$

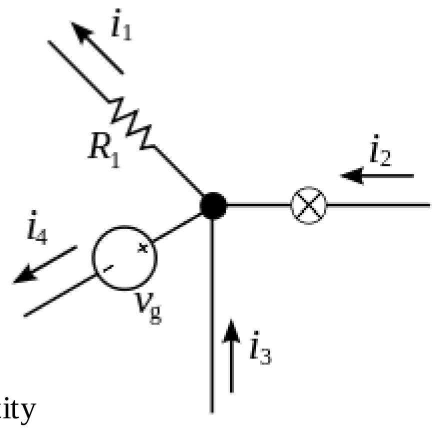
(iii) A new flashlight cell of emf 1.5V gives a current of 15A, when connected directly to an ammeter of resistance 0.04Ω. The internal resistance of cell is
a) 0.04Ω b) 0.06Ω c) 0.10Ω d) 10Ω

(iv) A student measures the terminal difference (V) of a cell (of emf ε and internal resistance **r**) as a function of the current (I) flowing through it. The slope, and intercept, of the graph between V and I , then, respectively, equal
a) ε and r b) – r and ε c) r and – ε d) – ε and r

(v) For a cell, the graph between the potential difference (V) across the terminals of the cell and the current (I) drawn from the cell is shown in the figure. The emf and the internal resistance of the cell are
a) 2V , 0.5Ω b) 2V, 0.4Ω
c) >2V, 0.5Ω d) >2V, 0.4Ω



38. Kirchhoff's current law

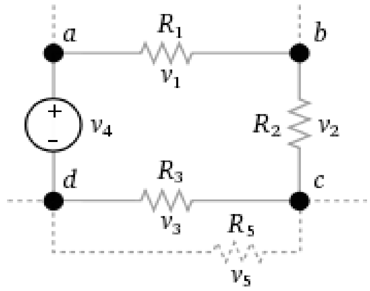


The current entering any junction is equal to the current leaving that junction. $i_2 + i_3 = i_1 + i_4$

This law, also called **Kirchhoff's first law**, or **Kirchhoff's junction rule**, states that, for any node (junction) in an electrical circuit, the sum of currents flowing into that node is equal to the sum of currents flowing out of that node;
or equivalently:

The algebraic sum of currents in a network of conductors meeting at a point is zero.

Recalling that current is a signed (positive or negative) quantity reflecting direction towards or away from a node, this principle can be succinctly stated as:



Kirchhoff's second law (Kirchhoff's voltage law):

The sum of all the voltages around a loop is equal to zero.

$v_1 + v_2 + v_3 + v_4 = 0$

This law, also called **Kirchhoff's loop rule**, states the following:

The directed sum of the potential differences (voltages) around any closed loop is zero.

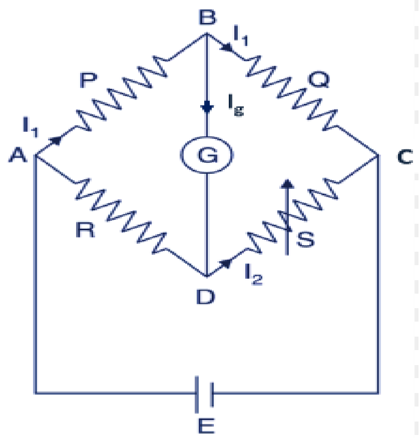
(i) According to Kirchhoff's law, in any analytical circuit, if the current is assumed opposite, then the value of current will be
a) (i) b) (2i) c) (-i) d) zero

(ii) Kirchhoff's first law at a junction is based on the law of conservation of
a) Charge b) energy c) momentum d) angular momentum

(iii) Kirchhoff's second law is based on the law of conservation of
a) Charge b) energy c) momentum d) sum of mass and energy

(iv) In a closed circuit, the vector sum of total emf is equal to the sum of the ________
a) Current c) Resistance
b) Product of current and resistance d) product of potential differences

39. WHEATSTONE BRIDGE: Wheatstone bridge, also known as the resistance bridge, calculates the unknown resistance by balancing two legs of the bridge circuit. One leg includes the component of unknown resistance.



The Wheatstone Bridge Circuit comprises two known resistors, one unknown resistor and one variable resistor connected in the form of a bridge. This bridge is very reliable as it gives accurate measurements.

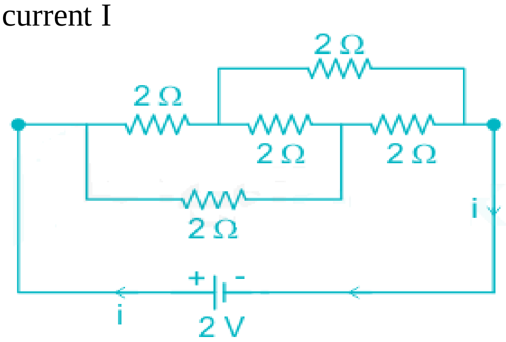
When bridge is balanced $V_B = V_D$ i.e. potential at B and D are same so no potential difference between B and D. Hence current across G is zero so $i_g = 0$. And we get this condition at

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

(i) In Wheatstone bridge, three resistors P,Q,R are connected in three arms in order as shown in above circuit and 4th arm S is formed by two resistors S_1 and S_2 connected in parallel. The condition for bridge to be placed is P/Q
a) $R(S_1+S_2)/S_1S_2$ c) $S_1S_2/R(S_1+S_2)$
b) $RS_1S_2/(S_1+S_2)$ d) $(S_1+S_2)/RS_1S_2$

(ii) Four conductors of resistance 4, 3, 9 and 6 ohm are connected in AB, BC, CD and DA arms of a Wheatstone bridge. The bridge can be balanced by connecting
a) 6 ohm in series with 3 ohm conductor
b) 4 ohm in parallel with 6 ohm conductor
c) 3 ohm in series with 3 ohm conductor
d) 5 ohm in series with 6 ohm conductor

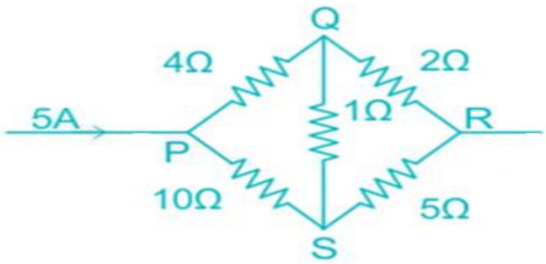
(iii) Find the value of current I



a) 4A b) 3A c)2A d)1A

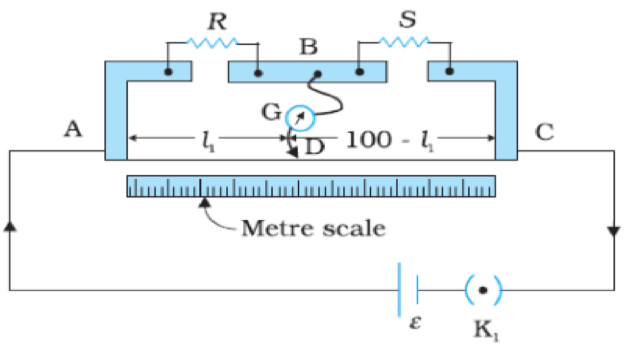
(iv) In a Wheatstone bridge, all the four arms have equal resistance R. If resistance of the galvanometer arm is also R, then equivalent resistance of the combination is
a) R b) 2R c) R/2 d) R/4

(v) In the following figure, the current flowing through 1Ω resistance is



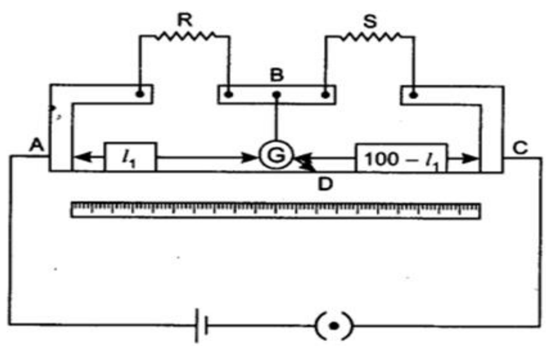
a) 0A b) $\frac{1}{5}$ A c) $\frac{25}{7}$A d) $\frac{7}{25}$A

40. Meter bridge: A meter bridge consists of a wire of length 1 m and of uniform cross-sectional area stretched taut and clamped between two thick metallic strips bent at right angles with two gaps across which resistors are to be connected. The end points where the wire is clamped are connected to a cell through a key.



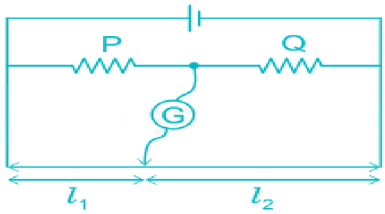
Its application of Wheatstone bridge and used in various ways.

(i) In a meter bridge, the point D is neutral point



a) The meter bridge can have other neutral point f
b) when the jockey contacts a point on meter wire left of D, current flows to B from the wire.
c) when the jockey contacts a point on the meter wire to the right of D, current flows from B to the wire through galvanometer.
d) When R is increased, the neutral point shifts to left.

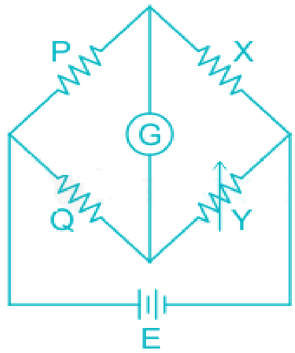
(ii) The meter bridge shown is in balance position with $\frac{P}{Q}=\frac{l_1}{l_2}$. If we now interchange the positions of galvanometer and cell, will the bridge work the same ? if yes, what will be the balance condition?



a) Yes, $\frac{P}{Q}=\frac{l_2}{l_1}$ c) Yes, $\frac{P}{Q}=\frac{l_1}{l_2}$

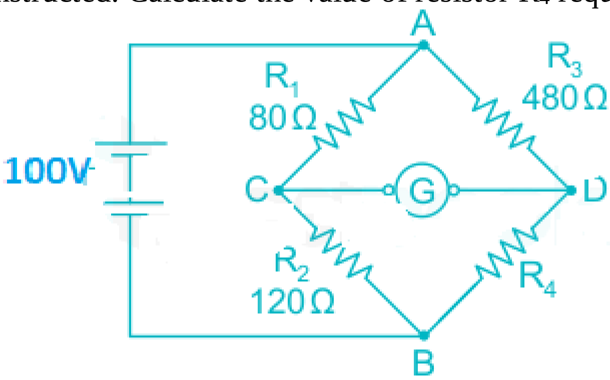
b) Yes, $\frac{P}{Q}=\frac{l_2-l_1}{l_2+l_1}$ d) no, no null point

(iii) A meter bridge is used to determine the value of unknown resistance X by adjusting the variable resistance Y as shown in the figure. For the most precise measurement of X, the resistances P and Q



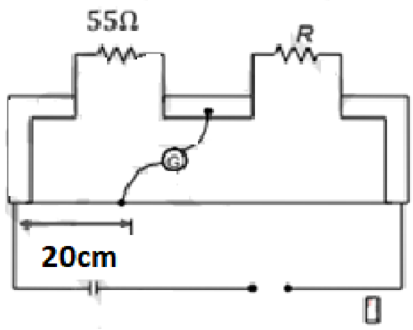
a) Do not play any significant role
b) Should be approximately equal to 2X
c) Should be approximately equal and are small
d) Should be very large and unequal

(iv) The following unbalanced Wheatstone bridge is constructed. Calculate the value of resistor R_4 required to balance the bridge circuit.



a) 560Ω b) 360Ω c) 720Ω d) 180Ω

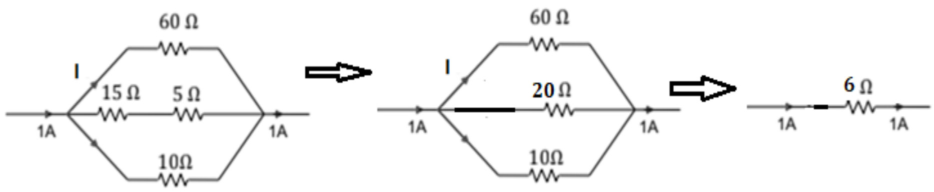
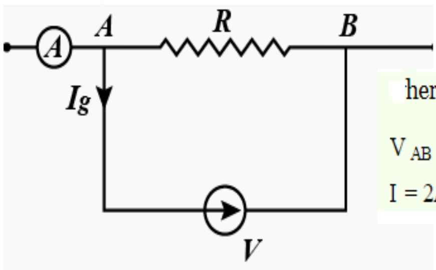
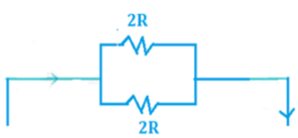
(v) Shown in the figure adjacent is a meter-bridge set up with null deflection in the galvanometer. The value of the unknown resistor R is

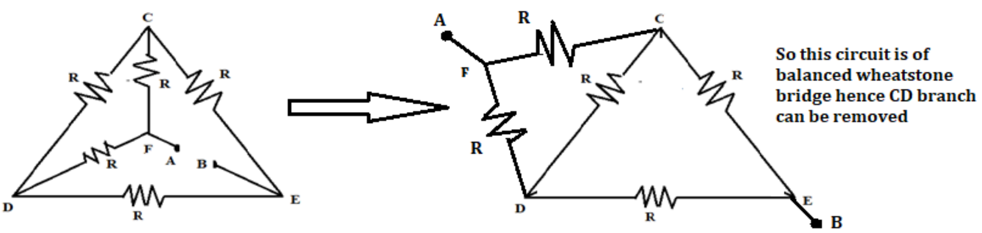
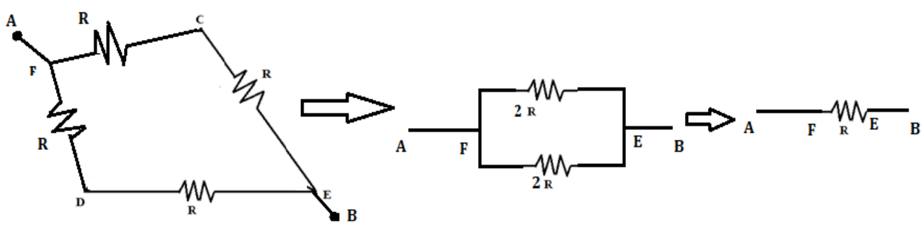


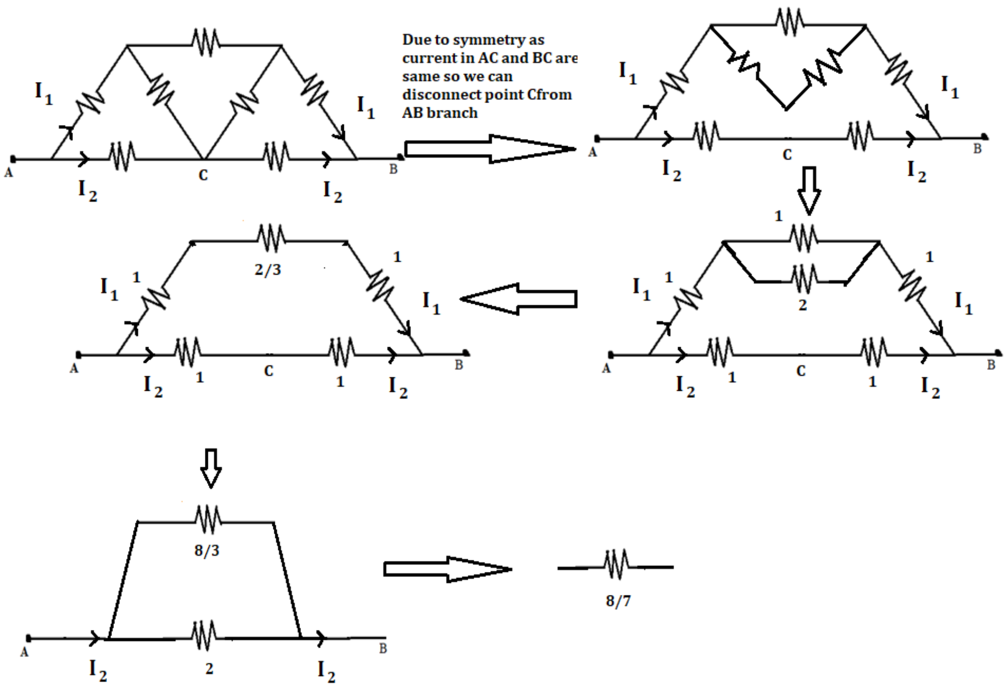
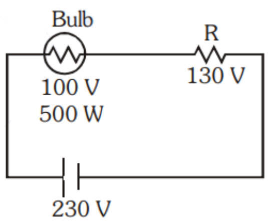
a) 13.75Ω
b) 110Ω
c) 220Ω
d) d) 55Ω

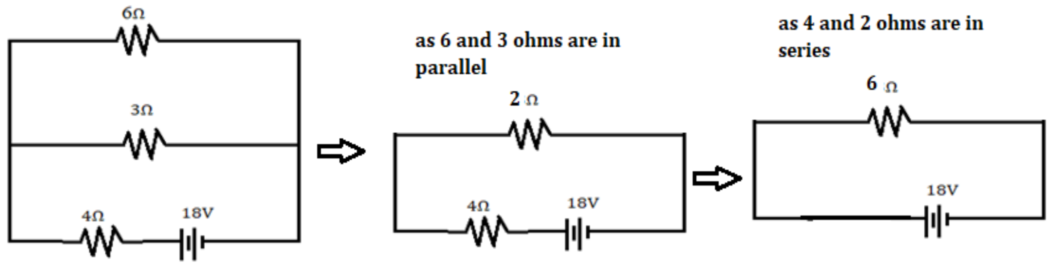
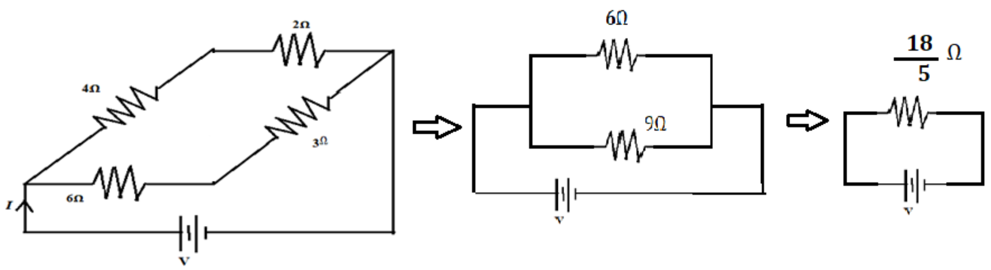
ANSWER KEY (CURRENT ELECTRICITY)

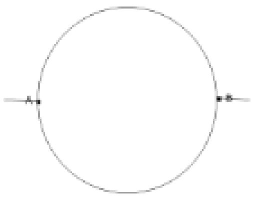
Q. No.	ANSWERS AND STEPS
1	c) 6Ω
2	a) $I_1 = I_2 = I_3$
3	e) 0.1

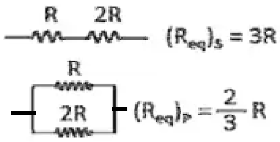
	 V= IR=1x6=6V potential difference in parallel is equal so, V = iR hence i = V/R = 6/60 = 0.1A
4	c) More than 10Ω  here, G = voltmeter resistance $V_{AB} = 20V$ $I = 2A$ and $R = R$ $V_{AB} = (I - I_g) \cdot R = I_g \cdot G$ $20 = (2 - I_g) \cdot R$ $R = \frac{20}{2 - I_g}$ **So, as denominator is less than 2A so R is more than 10 ohms**
5	e) Internal resistance equal to external resistance
6	b) 6Ω for 0 potential difference between B and D it should satisfy balanced Wheatstone bridge condition $\frac{P}{Q} = \frac{R}{S}$ here P,Q,R and S will be 12, (X+6), $\left(\frac{1\times1}{1+1}\right)$ *and* $\left(\frac{1\times1}{1+1}\right)$ Therefore $\frac{12}{(X+6)} = \frac{\left(\frac{1\times1}{1+1}\right)}{\left(\frac{1\times1}{1+1}\right)} = 1$ 12 = X+6 so, X = 6Ω
7	d) R=0 $I = \frac{\varepsilon}{R+r}$ For maximum I, (R+r) should be minimum. Hence R = 0 will give maximum current.
8	a) R   so equivalent resistance will be $\frac{1}{Ro} = \frac{1}{2R} + \frac{1}{2R}$ So, Ro = R

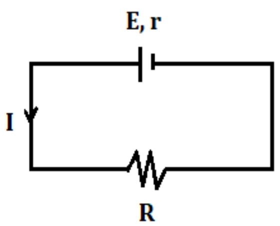
9	b) Conductivity
10	d) 14V Since the batteries are connected in parallel $V = \frac{E_1r_2 + E_2r_1}{r_1 + r_2} \Rightarrow V = \frac{18 \times 1 + 12 \times 2}{1+2} \Rightarrow V = 14V olt$
11	b) 3Ω The four resistances of Whetstone's bridge are 2, 2, 2 and $\frac{6S}{6+s}$ In case of a balanced bridge: $\Rightarrow \frac{2}{2} = \frac{2}{\frac{6S}{6+s}}$ $\Rightarrow$ 6s=2(6+s) $\Rightarrow$3s=6+s $\Rightarrow$2s=6 $\Rightarrow$s=3 Ohm
12	c) 20 In 1st case the balance condition is $(R_1+10)/R_2=(100-50)/50$ So $R_1+10=R_2$ .... (1) In 2nd case balance condition: $R_1/ R_2=40/(100-40) = 40/60 =2/3$ or $R_2=3R_1/2$ .... (2) From (1) and (2), $R_1+10=3R_1/2$ or $R_1=20\Omega$
13	a)R  So simplified circuit is 
14	c) 1V The potential drop across 3m will be 6V. Let the potential drop across 50cm be E. For uniform cross section of a homogenous wire potential per unit length is same

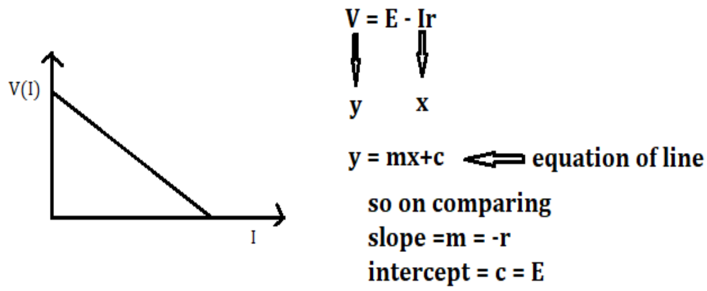
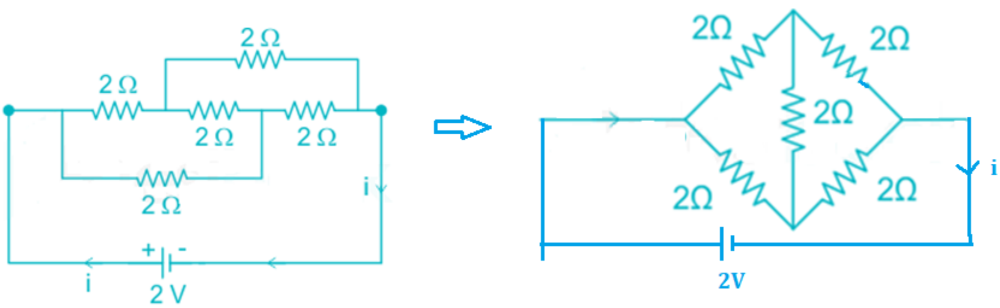
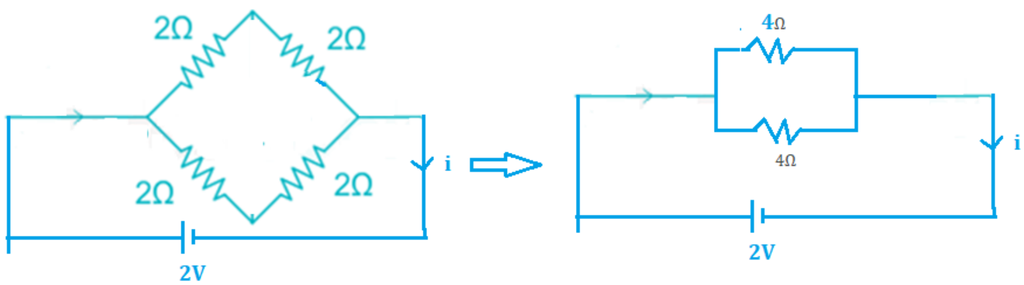
	Hence $\frac{E_1}{L_1} = \frac{E_2}{L_2}$ ⟹6/3=E/0.5 E=2×0.5=1V
15	d) $\frac{8}{7}\Omega$ 
16	a) 26Ω Power rating $=\frac{V^2}{R}$ so, $R = \frac{V^2}{P} = \frac{100^2}{500}$ = 20Ω and current for this rating $P = VI\ so,\ I = \frac{P}{V} = 5A$ Now, when bulb connected with R and works perfectly that means voltage across bulb is 100V and current in it is 5A.  So, R=$\frac{V}{I} = \frac{130}{5} = 26\Omega$
17	c) 54

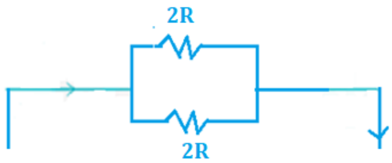
	 $P = \frac{V^2}{R} = \frac{18^2}{6} = 54\, watt$
18	d) 20 watt $P = \frac{V^2}{R}$ $so,$ $R = \frac{V^2}{P} = \frac{200^2}{60}$ In series $R_{eq} = R_1 + R_2 + R_3 = 3 \times \frac{200^2}{60} = 2000\Omega$ $P_{eq} = \frac{V^2}{R_{eq}} = \frac{200^2}{2000}$=20 watt.
19	b) 40Ω Resistance of a wire $R = \frac{\rho l}{A}$ where ρ= resistivity, *l* = length, A= cross section of the wire. As both have same material and length so $R \propto \frac{1}{A}$ Thus, $\frac{R_1}{R_2} = \frac{A_2}{A_1} = \frac{1}{3}$ ⇒ $R_2 = 3R_1$. here R_1 is the resistance of thicker wire so its resistance R_1=10Ω (given) so, R_2 = 3(10) = 30Ω As they are connected in series so the equivalent resistance is $R_{eq}=R_1+R_2$=10+30=40Ω
20	d) $\frac{5}{18}V$ as the bridge is balanced so,  $i = \frac{V}{R_{eq}} = \frac{5V}{18}$
21	b) Wire of cross-sectional area 2A $R = \frac{\rho l}{A}$ so R_1=R $R_2 = \frac{\rho(2l)}{\left(\frac{A}{2}\right)} = 4R$

	$R_3 = \frac{\rho(\frac{l}{2})}{(2A)} = \frac{R}{4}$
22	b) CD
23	d) 0.6πΩ  Circumference of circle $= 2 \times \pi \frac{10}{100} = \frac{2\pi}{10} = \frac{\pi}{5}$ Resistance of wire $= 12 \times \frac{\pi}{5} = \frac{12\pi}{5}$ Resistance of each section $= \frac{12\pi}{10}\,\Omega$ therefore, Equivalent resistance $= \frac{\frac{12\pi}{10} \times \frac{12\pi}{10}}{\frac{12\pi}{10} + \frac{12\pi}{10}} = \frac{6\pi}{10} = 0.6\,\pi\Omega$
24	(a) the current through each resistance is same.
25	(b) not change
26	(d) the average of the velocities of all the free electrons at an instant is zero
27	b $V = E - Ir$ $V = E - \left(\frac{E}{r+R}\right) r$ $V = E[1 - \frac{r}{r+R}]$ $V = E[1 - \frac{1}{1+\frac{R}{r}}]$ So as R increases V also increases but not linearly and maximum value of V is E.
28	b
29	c
30	c
31	a
32	c
33	(i) b) 4 Let the resistance of the whole wire = R We know, $P_1 = \frac{V^2}{R}$ Now after cutting the wire into two equal pieces the resistance of each piece = R/2 Equivalent resistance parallel combination $\frac{\frac{R}{2} \times \frac{R}{2}}{\frac{R}{2} + \frac{R}{2}} = \frac{R}{4}$ so, $P_2 = \frac{V^2}{\frac{R}{4}}$ $\Rightarrow P_2 = \frac{4V^2}{R}$ $\Rightarrow P_2 = 4P_1$ $\Rightarrow P_2 : P_1 = 4$ (ii) b) 9 $P_1 = \frac{V^2}{R}$ so, $6 = \frac{V^2}{6}$ hence V=6 V Now in parallel voltage remains same $P_2 = \frac{V^2}{R}$ = 6 x 6/4 = 9 (iii) b) 1:6

	$A_A : A_B = 1 : 6$ $H = V^2t/R$ and $R = \frac{pl}{A}$ $H_A = \frac{v^2t}{pl/A_A}; H_B = \frac{V^2t}{pl/A_B}$ **So,** $\frac{H_A}{H_B} = \frac{v^2t \times A_A}{pl} \times \frac{pl}{V^2tA_B}$ ⇨ $\frac{H_A}{H_B} = \frac{A_A}{A_B} =$ **1:6** (iv) d) 9:2  ; $H = \frac{V^2}{R}t$ **hence** Heat generated α R $\frac{H_s}{H_p} = \frac{3R}{\frac{2}{3}R} = \frac{9}{2}$ (v) d) P/4 [Hint : Resistance of heater element $R = \frac{V^2}{P}$. For voltage$n\frac{V}{2}$, the power consumed $P. = \frac{(V/2)^2}{R} = \frac{V^2}{4R} = \frac{P}{4}$
34	(i) b) 1A away from x as per Kirchhoff's junction law $\sum i_n = 0$ so, 5A+4A+i-5A-3A = 0 i = - 1A So, 1A away from X (ii) a) X to Y (iii) a) X to Y (iv) b) E to O, O to D and O to A As current flows from high potential to low potential (v) b) $i_2 + i_3$ (vi) c) 23A
35	(i) b) R/4 $R = \frac{\rho L}{A}$ As resistance and area are inversely proportional So when area becomes 4 times then resistance becomes one fourth. (ii) b) 0.0367mm $R = 2\Omega, \ \rho = 1.7 \times 10^{-8}\Omega m, \ l = 50cm = 50 \times 10^{-2}m$ $r = ?$ $R = \frac{\rho l}{\pi r^2}$ $r^2 = \frac{\rho l}{\pi R} \Rightarrow r = \sqrt{\frac{\rho l}{\pi R}}$ $r = \sqrt{\frac{1.7 \times 10^{-8} \times 50 \times 10^{-2}}{3.14 \times 2}} = 0.0367 \times 10^{-3}m$ = 0.0367 mm (iii) d) potential difference (iv) b) 0.25R diameter α radius area α $(radius)^2$ resistance α $\frac{1}{radius^2}$ so if diameter doubles, then radius doubles and area becomes four times

		so resistance becomes one fourth i.e, 0.25 times
	(v)	c) 16:1 Current flowing through the conductor, $I= neAv_d$ Hence $\frac{4}{1} = \frac{nev_1\pi 1^2}{nev_2\pi 2^2}$ $\frac{v_1}{v_2} = \frac{4\times 4}{1}$ =16:1
	(vi)	c) The resistance will be halved; the specific resistance will remain unchanged. $R = \frac{\rho l}{A} = \frac{\rho l}{\pi r^2}$ $R' = \frac{\rho(2l)}{\pi(2r)^2} = \frac{1}{2}\frac{\rho l}{\pi r^2} = \frac{1}{2}R$
36	(i)	d) The average speed of the electron between successive collisions in the direct opposite to the applied electric field.
	(ii)	b) Decreases, thermal velocity of electron increases
	(iii)	a) Be doubled the initial velocity $v_d = a\tau$ $a = \frac{eE}{m}$ $v_d = \frac{eV\tau}{ml}$ So drift velocity is directly proportional to potential difference
	(iv)	b) Decreases with increase in temperature
	(v)	a) Drift velocity alone
	(vi)	b) Will remain the same
	(vii)	d) $v_d/4$ $I = neAv_d$ $I = ne(\pi r^2)v_d$ $v_d = \frac{I}{ne(\pi r^2)}$ As drift velocity is inversely proportional to square of radius So, when radius doubles then drift velocity becomes one fourth.
	(viii)	d) The average of the velocities of all the free electrons at an instant is zero
37	(i)	b) Equal to its emf
	(ii)	d) $V_T = \varepsilon$
	(iii)	b) 0.06Ω  $I = \frac{E}{R+r}$ $r = \frac{E}{I} - R$ r = 0.06 Ω
	(iv)	b) –r and E

		
	(v)	b) 2V, 0.4Ω as intercept is 2V so emf is 2V slope =- r slope = -2/5 so, r = 2/5 = 0.4Ω
38	(i) (ii) (iii) (iv)	c) (-i) a) Charge b) energy b) Product of current and resistance
39	(i)	a) $R(S_1+S_2)/S_1S_2$
	(ii) (iii)	c) 3 Ω in series with 3 Ω conductor d)1A
		 As the bridge is balanced so  So equivalent resistance is 2Ω And $i = \frac{V}{R} = \frac{2}{2} = 1A$
	(iv)	a) R 

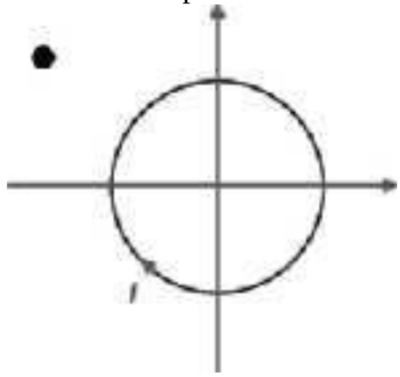
		 so equivalent resistance will be $\frac{1}{R_o} = \frac{1}{2R} + \frac{1}{2R}$ So, Ro = R
	(v)	a) 0A as the bridge is balanced so potential at Q = potential at S Hence, current in 1Ω resistance will be zero.
40	(i)	c) When the jockey contacts a point on the meter wire to the right of D, current flows from B to the wire through galvanometer.
	(ii)	c) Yes, $\frac{P}{Q} = \frac{l_1}{l_2}$
	(iii)	c) Should be approximately equal and are small
	(iv)	c) 720Ω
	(v)	c) 220Ω

UNIT-III- MAGNETIC EFFECTS OF CURRENT & MAGNETISM

MCQs - Chapter 4: Moving Charges and Magnetism

1. A voltmeter has a range 0-V with a series resistance of R Ω. With a series resistance of 2R, its range is 0-V'. The correct relation between V and V' is
   a) V = 2V b) V' > 2V c) V' > 2V d) V < 2V
2. The magnetic field due to a current-carrying circular loop of radius 3 cm at a point on the axis at a distance of 4 cm from the center is 54 pT. What will be its value at the center of the loop?
   a) 125 µT b) 75 µT c) 250 µT d) 150 µT
3. A galvanometer of resistance 25Ω is shunted by a 2.5Ω wire. The part of total current Io that flows through the galvanometer is given by
   a) $\frac{I}{I_o} = \frac{2}{11}$ b) $\frac{I}{I_o} = \frac{4}{11}$ c) $\frac{I}{I_o} = \frac{1}{11}$ d) $\frac{I}{I_o} = \frac{3}{11}$
4. A uniform electric field and a uniform magnetic field are produced, pointed in the same direction. When an electron is projected with its velocity pointed in the same direction,
   a) the electron velocity will decrease in magnitude
   b) the electron velocity will increase in magnitude
   c) the electron velocity will turn it into left
   d) the electron velocity will turn it into right
5. A panicle having charge 100 times that of an electron is revolving in a circular path by radius 0.8 m with one rotation per second. The magnetic field produced at the center is:
   a) $10^{-16}\mu_o$ b) $10^{17}\mu_o$ c) $10^{-15}\mu_o$ d) $10^{-17}\mu_o$
6. The magnetic field in a circular loop of diameter 0.1 m carrying a current of 1 A is
   a) $3.8 \times 10^{-5}\ T$ b) $4.4 \times 10^{-5} T$ c) $1.25 \times 10^{-5} T$ d) $2.8 \times 10^{-5}\ T$
7. A wire of length L carrying current i is placed perpendicular to the magnetic induction B. The total force on the wire is
   a) LB/i b) iL /B c) iLB d) iB/ L

8. A conducting loop carrying a current I is placed in a uniform magnetic field pointing into the plane of the paper as shown. The loop will have a tendency to



a) Contract b) Expand
c) Move towards +ve X – axis d) Move towards –ve X – axis

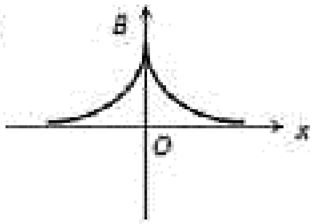
9. Two circular coils are made of two identical wires of same length. If the number of turns of two coils is 4 and 2, then the ratio of magnetic induction at centres will be zero.
a) 4 : 1 b) 2 :1 c) 1 : 2 d) 1:1

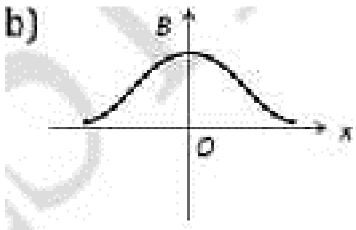
10. An electron ($e = 1.6 \times 10^{-19}$C) moves in a circular orbit of radius 1.42 cm with a speed of 10 cm/s in presence of magnetic field of 4×10^{-2}T. If the mass of electron is 9.1×10^{-31} kg the energy gained by the electron in going one round the circular orbit is
a) Zero b) 4.54×10^{-28} J c) 9.08×10^{-28} J d) 28.55×10^{-28} J

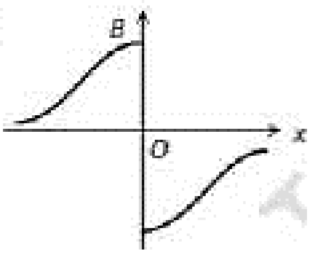
11. An ammeter has resistance R_o and range I. What resistance should be connected in parallel with it to increase its range by n times?
a) $R_o/(n - 1)$ b) $R_o/(n + 1)$ c) R_o/n d) None of these

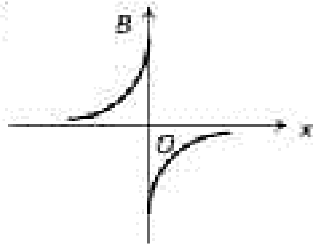
12. A straight wire of length 0.5 m and carrying a current of 1.2 A is placed in a uniform magnetic field of induction 2 T. The magnetic field is perpendicular to the length of the wire. The force on the wire is
a) 2.4 N b) 1.2 N c) 3.0 N d) 2.0 N

13. A circular coil is in Y-Z plane with centre at origin. The coil is carrying a constant current Assuming direction of magnetic field at x = -25 cm to be positive direction of magnetic field, which of the following graphs shows variation of magnetic field along X-axis?

a) 

b) 

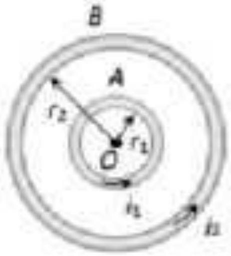
c) 

d) 

14. A deuteron of kinetic energy 50 keV is describing a circular orbit of radius 0.5 m in a plane perpendicular to magnetic field B. The kinetic energy of the proton that describes a circular orbit of radius 0.5 m in the same plane with the same B is

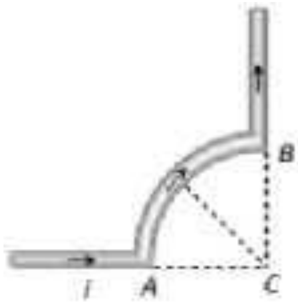
a) 200 keV b) 100 keV c) 50 keV d) 25 keV

15. *A* and *B* are two concentric circular conductors of centre *O* and carrying currents i_x and i_2 as shown in the adjacent figure. If ratio of their radii is 1 : 2 and ratio of the flux densities at *O* due to *A* and *B* is 1: 3, then the value of i_1/i_2 is



a) 1/6 b)1/4 c) 1/3 d) 1/2

16. A wire carrying current i is shaped as shown. Section AB is a quarter circle of radius r. The magnetic field is directed



a) At an angle π/4 to the plane of the paper
b) Perpendicular to the plane of the paper and directed in to the paper
c) Along the bisector of the angle ACB towards AB
d) Along the bisector of the angle ACB away from AB

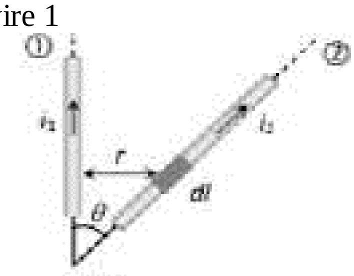
17. A rectangular loop carrying a current i is placed in a uniform magnetic field B. The area enclosed by the loop is A. If there are n turns in the loop, the torque acting on the loop is given by

a) $ni\vec{A} \times \vec{B}$ b) $ni\vec{A} . \vec{B}$ c) $\frac{1}{n}(i\vec{A} \times \vec{B})$ d) $\frac{1}{n}(ni\vec{A} . \vec{B})$

18. Two long parallel wires P and Q are both perpendicular to the plane of the paper with distance 5 m between them. If P and Q carry current of 2.5 A and 5 A respectively in the same direction, then the magnetic field at a point halfway between the wires is

a) $\frac{\sqrt{3}\mu_o}{2\pi}$ b) $\frac{\mu_o}{\pi}$ c) $\frac{3\mu_o}{2\pi}$ d) $\frac{\mu_o}{2\pi}$

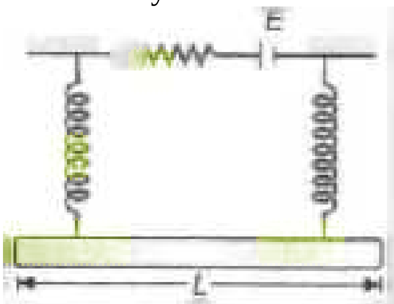
19. Wires 1 and 2 carrying currents i_x and i_2 respectively are inclined at an angle 0 to each other. What is the force on a small element dl of wire 2 at a distance of r from wire 1 (as shown in figure) due to the magnetic field of wire 1



a) $\frac{\mu_o}{2\pi r} i_1 i_2$ dl $\tan\theta$ b) $\frac{\mu_o}{2\pi r} i_1 i_2$ dl $\sin\theta$

b) $\frac{\mu_o}{2\pi r} i_1 i_2$ dl $\cos\theta$ d) $\frac{\mu_o}{4\pi r} i_1 i_2$ dl $\sin\theta$

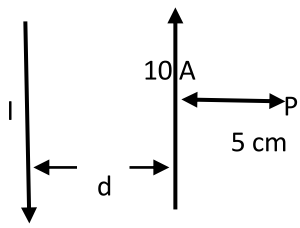
20. A straight rod of mass m and length L is suspended from the identical springs as shown in figure. The spring is stretched a distance X_o due to the weight of the wire. The circuit has total resistance R. When the magnetic field perpendicular to the plane of paper is switched on, springs are observed to extend further by the same distance. The magnetic field strength is



a) $\frac{2mgR}{LE}$ b) $\frac{mgR}{LE}$ c) $\frac{mgR}{2LE}$ d) $\frac{mgR}{E}$

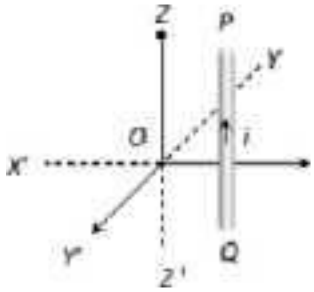
21. Two concentric coils each of radius equal to 2π cm are placed at right angles to each other. 3A and 4A are the currents flowing in each coil respectively. The magnetic induction in Wbm^{-2} at the centre of the coils will be ($\mu_o = 4\pi \times 10^{-7}$ $WbAm^{-1}$)
a) 12×10^{-5} b) 10^{-5} c) 5×10^{-5} d) 7×10^{-5}

22. Two long parallel conductors carry currents in opposite directions as shown. One conductor carries a current of 10A and the distance between the wires is d = 10 cm. Current I is adjusted, so that the magnetic field at P is zero. P is at a distance of 5 cm to the right of the 10 A current. Value of I is



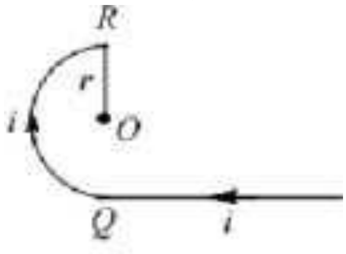
a) 40A b) 30A C) 20A d) 10A

23. A vertical wire kept in *Z-X* plane carries a current from *Q* to *P* (see figure). The magnetic field due to current will have the direction at the origin *0* along
a) OX b) OX' c) OY d) OY'



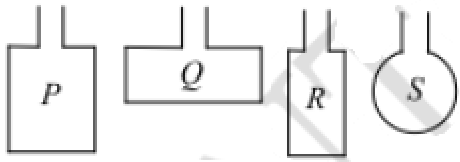
24. 3A of current is flowing in a linear conductor having a length of 40 cm. The conductor is placed in a magnetic Field of strength 500 gauss and makes an angle of 30° with direction of the field. It experiences a force of magnitude
a) 3×10^{-4} N b) 3×10^{2} N c) 3×10^{-2} N d) 3×10^{-4} N

25. The magnetic field induction at the centre O, in the arrangement shown in figure is



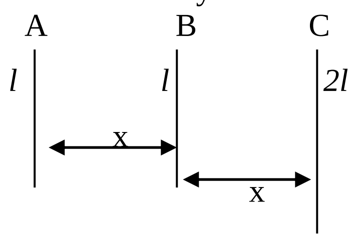
a) $\frac{\mu_o\, i}{4\pi\, r}\ (4+\ \pi)$ b) $\frac{\mu_o\, i}{4\pi\, r}\ (3+\ \pi)$
c) $\frac{\mu_o\, i}{4\pi\, r}\ (2+\ \pi)$ d) $\frac{\mu_o\, i}{4\pi\, r}\ (1+\ \pi)$

26. Four wires each of length 2.0 m are bent into four P, Q, R and 5 and then suspended into a uniform magnetic field. Same current in passed in each loop



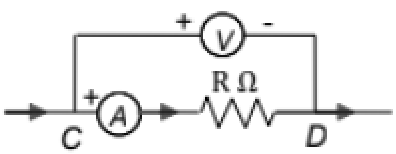
a) $\frac{B\, m\, i}{l}$ b) $m\, B\, i\, l$ c) $\frac{B\ i\, l}{m}$ d) $\frac{m\, i\, l}{B}$

27. A, B and C are parallel conductors of equal length carrying currents *l*, *l and 2l* respectively. Distance between A and B is x. Distance between B and C is also x. F_1 is the force exerted by B on A and F_2 is the force exerted by C on A. Choose the correct answer



a) $F_1 = 2F_2$ b) $F_2 = 2\, F_1$ c) $F_1 =\ F_2$ d) $F_1 =\ -F_2$

28. A candidate connects a moving coil voltmeter V and a moving coil ammeter A and resistor R as shown in figure?



If the voltmeter reads 10 V and the ammeter reads 2 A and then R is
a) Equal to 5 Ω b) Greater than 5 Ω
c) Less than 5 Ω d) Greater or less than 5 Ω depending upon its material

29. A particle of mass *m* and charge *q* released from the origin in a region occupied by electric field *E* and magnetic field *B*,
$B = -B_o\hat{j}\,, E =\ E_o\hat{\imath}$ The velocity of the particle will be

a) $\sqrt{\frac{2\, q\, E_o}{m}}$ b) $\sqrt{\frac{q\, E_o}{m}}$ c) $\sqrt{\frac{q\, E_o}{2\, m}}$ d) None of these

ASSERTION–REASON TYPE QUESTIONS

Each question contains STATEMENT – 1 (Assertion) and STATEMENT – 2 (Reason). Each question has 4 choices (A), (B), (C) and (D) out of which ONLY ONE is correct. So select the correct choice:

Choices are:
(A) Statement – 1 is True, Statement – 2 is True; Statement – 2 is a correct explanation for Statement – 1.
(B) Statement – 1 is True, Statement – 2 is True; Statement – 2 is NOT a correct explanation for Statement – 1.
(C) Statement – 1 is True, Statement – 2 is False.
(D) Statement – 1 is False, Statement – 2 is True.

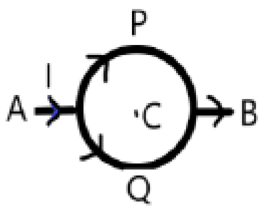
30. STATEMENT – 1: For a charged particle describing uniform circular motion in a magnetic field $T^2 \alpha r^3$ (symbols have their usual meanings)

STATEMENT – 2: The relation $T^2 \alpha r^3$ is valid only when $F \propto \frac{1}{r^2}$

31. STATEMENT – 1: A current loop is a magnetic dipole.

STATEMENT – 2: The net force on a current loop in a uniform magnetic field is zero

32. STATEMENT --1: The magnetic field at the centre of the current carrying circular coil shown in the fig. is zero.



STATEMENT-2: The magnitudes of magnetic fields are equal and the directions of magnetic fields due to both the semicircles are opposite.

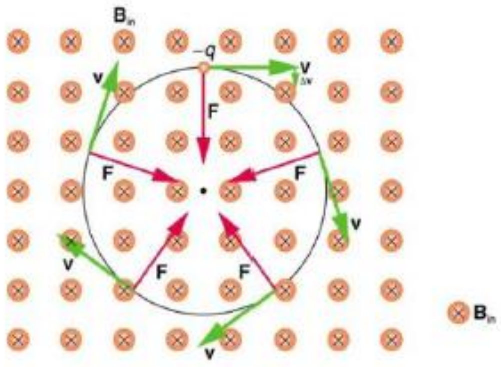
33. STATEMENT 1: A phosphor bronze strip is used in a moving coil galvanometer.

STATEMENT 2: Phosphor bronze strip has the maximum value of torsional constant k.

34. CASE STUDY BASED QUESTION

MOTION OF A CHARGED PARTICLE IN A UNIFORM MAGNETIC FIELD

A charged particle of mass m and charge q moves with a constant velocity along the positive X-direction $v = a\hat{i}$. It enters a region of magnetic field which is directed towards positive Z- direction from **x= a** which is given by $B=b\hat{k}$.



1. The initial acceleration of the particle is

a) $a = -\frac{qab}{m}\hat{\imath}$ b) $a = -\frac{qam}{b}\hat{\jmath}$ c) $a = -\frac{qa}{mb}\hat{\jmath}$ d) none of these

2. The radius of the circular path which the particle moves is

a) $\frac{mb}{qa}$ b) $\frac{ma}{qb}$ c) $\frac{mab}{q}$ d) none of these

3. Which of the following is true about the motion of the particle in uniform magnetic field, where the charged particle enters at right angles to the field?

(a) Force will always be perpendicular to the velocity.

(b) Kinetic energy of the particle remains constant.

(c) Velocity vector and magnetic field vector remains perpendicular to each other during the motion.

(d) All of these.

4. The frequency of the rotation

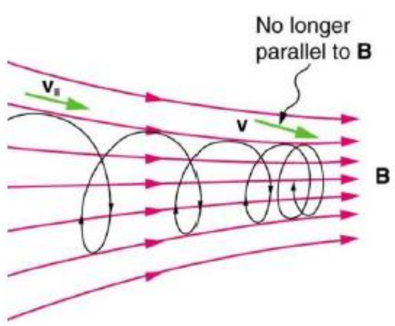
(a) depends on the value of a

(b) depends on the value of b

(c) depends on the value of a and b both

(d) does not depend on a and b

5. A particle moves in a region having a uniform magnetic field and a parallel, uniform electric field. At some instant, the velocity of the particle is perpendicular to the field direction. The path of the particle will be

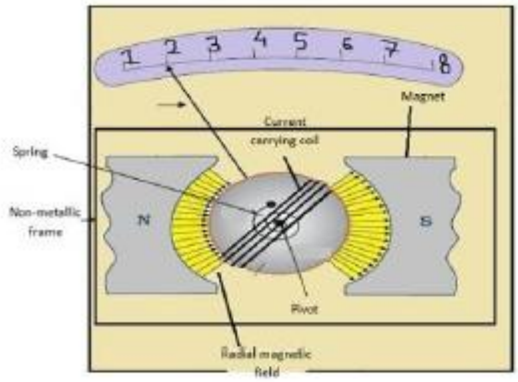


(a) A straight line (b) A circle

(c) A helix with uniform pitch (d) A helix with non-uniform pitch

35. SOURCE BASED QUESTION

The galvanometer is a device used to detect the current flowing in a circuit or a small potential difference applied to it. It consists of a coil with many turns, free to rotate about a fixed axis, in a uniform radial magnetic field formed by using concave pole pieces of a magnet. When a current flows through the coil, a torque acts on it.



1. What is the principle of moving coil galvanometer?
   (a) Torque acting on a current carrying coil placed in a uniform magnetic field.
   (b) Torque acting on a current carrying coil placed in a non-uniform magnetic field.
   (c) Potential difference developed in the current carrying coil.
   (d) None of these.
2. If the field is radial, then the angle between magnetic moment of galvanometer coil and the magnetic field will be
   (a) 0° (b) 30° (c) 60° (d) 90°
3. Why pole pieces are made concave in the moving coil galvanometer?
   (a) to make the magnetic field radial.
   (b) to make the magnetic field uniform.
   (c) to make the magnetic field non-uniform.
   (d) none of these.
4. What is the function of radial field in the moving coil galvanometer?
   (a) to make the torque acting on the coil maximum.
   (b) to make the magnetic field strong.
   (c) to make the current scale linear.
   (d) all the above.
5. If the rectangular coil used in the moving coil galvanometer is made circular, then what will be the effect on the maximum torque acting on the coil in magnetic field for the same area of the coil?
   (a) remains the same
   (b) becomes less in circular coil

(c) becomes greater in circular coil

(d) depends on the orientation of the coil

Chapter 5: MAGNETISM & MATTER

36. 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 x 10^{-2} J. What is the magnitude of magnetic moment of the magnet?

a) 0.26 J/T b) 0.36 J/T c) 0.43 J/T d) 0.30 J/T

37. According to Gauss's law for magnetism

a) $\oint \vec{B}.\overrightarrow{ds} = 0$ b) $\oint \vec{B}\ X\ \overrightarrow{ds} = 0$ c) $\oint \vec{B}.\overrightarrow{ds} = \mu_o$ d) $\oint \vec{B} X\ \overrightarrow{ds} = \mu_o$

38. The force between two magnetic poles is F. If the distance between the poles and pole strengths of each pole are doubled, then the force experienced is :

a) F b) F / 4 c) 2F d) F / 2

39. The magnetic moment of a diamagnetic atom is

a) Equal to one b) Between zero and one

c) Equal to zero d) Much greater than one

40. A short bar magnet has a magnetic moment 1.2 Am^2. The magnetic field at a distance 0.1 m on its axis will be (μ_o = 4π x 10^{-7}T.m / A)

a) 1.2 x 10^{-4} T b) 2.4 x 10^{-4} T c) 2.4 x 10^{4} T d) 1.2 x 10^{4} T

41. A cube-shaped permanent magnet is made of a ferromagnetic material with a magnetization M of 4 x 10^5 A/m. The side length is 2 cm. Magnetic field due to the magnet at a point 10 cm from the magnet along its axis is

a) 0.003T b) 0.001T c) 0.002T d) 0.004T

42. A closely wound solenoid of 2000 turns and area of cross-section 1.6 x 10^{-4} m^2, carrying a current of 4.0 A, is suspended through its centre allowing it to turn in a horizontal plane. What is the magnetic moment associated with the solenoid?

a) 3.18 Am^2 b) 2.08 Am^2 c) 1.28 Am^2 d) 4.38 Am^2

43. A paramagnetic sample shows a net magnetization of 8 Am^{-1} when placed in an external magnetic field of 0.6T at a temperature of 4K. When the same sample is placed in an external magnetic field of 0.2T at a temperature of 16K, the magnetization will be

a) 6 Am^{-1} b) 2/3 Am^{-1} c) 2.4 Am^{-1} d) 32/3Am^{-1}

44. A bar magnet of magnetic moment M, is placed in a magnetic field B. The torque exerted on it is:

a) $\vec{M}\ X\ \vec{B}$ b) $\vec{M}\ .\vec{B}$ c) $-\ \vec{B}\ .\vec{M}$ d) $-\overrightarrow{M\varepsilon}\ .\vec{B}$

45. Relative permittivity and permeability of a material are ε_r and respectively. Which of the following values of these quantities are allowed for a diamagnetic material?

a) $\varepsilon_r = 1.5,\ \mu_r = 1.5$ b) $\varepsilon_r = 0,\ \mu_r = 1.5$

c) $\varepsilon_r = 1.5,\ \mu_r = 0.5$ d) $\varepsilon_r = 0.5,\ \mu_r = 0.5$

46. An iron bar magnet of length 10 cm and cross-section 1 cm^2 has a magnetization of 10^2 A/m. Magnet's pole strength is

a) 0.0025 Am b) 0.0015 Am c) 0.01 Am d) 0.002 Am

47. A short bar magnet has a magnetic moment of 0.48 J/T. Magnetic field produced by the magnet at a distance of 10 cm from the centre of the magnet on the equatorial lines (normal bisector) of the magnet has a direction and magnitude of

a) 0.43 G along N-S direction b) 0.38 G along N-S direction

c) 0.55 G along N-S direction d) 0.48 G along N-S direction

ASSERTION–REASON TYPE QUESTIONS

Each question contains STATEMENT – 1 (Assertion) and STATEMENT – 2 (Reason). Each question has 4 choices (A), (B), (C) and (D) out of which ONLY ONE is correct. So select the correct choice :

Choices are:

(A) Statement – 1 is True, Statement – 2 is True; Statement – 2 is a correct explanation for Statement – 1.

(B) Statement – 1 is True, Statement – 2 is True; Statement – 2 is NOT a correct explanation for Statement – 1.

(C) Statement – 1 is True, Statement – 2 is False.

(D) Statement – 1 is False, Statement – 2 is True.

48. **Statement 1**: Basic difference between an electric line and magnetic line of force is that former is discontinuous and the latter is continuous or endless

Statement 2: No electric lines of forces exists inside a charged conductor but magnetic lines do exist inside a magnet

49. **Statement 1**: The ferromagnetic substance obeys Curie-Weiss law.

Statement 2: The magnetic susceptibility of a ferromagnetic substance varies inversely as the absolute temperature.

50. CASE STUDY / SOURCE BASED QUESTION

According to Neil Bohr's atom model, the negatively charged electron is revolving around a positively charged nucleus in a circular orbit of radius r. The revolving electron in a closed path constitutes an electric current. The motion of the electron in anticlockwise direction produces conventional current in the clockwise direction. Current, I = e/T where T is the period of revolution of the electron. If v is the orbital velocity of the electron, then Due to the orbital motion of the electron, there will be orbital magnetic moment μ_l

$$\mu_L = IA, where\ A\ is\ the\ area\ of\ the\ orbit$$

$\mu_l = \frac{ev}{2\pi r}\pi r^2 = \frac{evr}{2}$. If m is mass of electron then $\mu_l = \frac{e}{2m}(mvr) = \frac{e}{2m}l$ where mvr = l called angular momentum of the electron about the central nucleus. Bohr hypothesized that the angular momentum of the orbiting electron has only discrete values given by the equation. $l = \frac{nh}{2\pi}$

Substituting this in above equation magnetic moment of orbiting electron is

$\mu_l = \frac{e}{2m}\frac{nh}{2\pi} = \frac{neh}{4\pi m}$ The minimum value of magnetic moment is $(\mu_l)_{min} = \frac{eh}{4\pi m}$. This value is called Bohr magneton. By substituting the values of e, h and m the value of Bohr magneton is 9.27 x 10^{-24} Am^2.

1. If an electron in an atom revolves around a nucleus in clockwise manner, the direction of circulating current in the orbit is

   a) Clockwise direction
   b) Perpendicular direction w.r.t orbit
   c) Anti-clockwise direction
   d) none of the above

2. The value of Gyromagnetic ratio is

   a) 88 × 10^9 C kg^{-1} b) 8.8 × 10^{10} C g^{-1} c) 8.8 × 10^{10}mC kg^{-1} d) All of the above 3

3. Angular momentum of an electron in an orbit mainly depends on

   a) Radius of the orbit
   b) Velocity of electron in orbit
   c) Principal quantum number
   d) None of the above

4. The minimum value of magnetic moment of revolving electron is

   a) eh/4m b) ehm/4 c) eh/4πm d) None of the above

5. The SI unit of magnetic moment of electron is

   a) Am^2 b) A^2m^2 c) A^2m d)Am

ANSWER KEY (Ch-4 & 5-MCQS)

1.	D	2.	C	3.	C	4.	A	5.	D	6.	C	7.	A	8.	B	9.	A	10.	A
11.	C	12.	B	13.	B	14.	B	15.	A	16.	B	17.	A	18.	D	19.	C	20.	B
21.	C	22.	B	23.	D	24.	B	25.	D	26.	D	27.	D	28.	C	29.	A	30.	D
31.	B	32.	A	33.	C	34.	Key	35.	key	36.	B	37.	A	38.	A	39.	C	40.	A
41.	B	42.	C	43.	B	44.	A	45.	C	46.	C	47.	D	48.	B	49.	C	50.	Key

SOLUTIONS (Ch-4 & 5)

1. (d) V’ < 2V

   Explanation: In the first case. V = Ig(G + R) where, G is the resistance of the galvanometer, Ig is the current for full scale deflection and R is the series resistance. In the second case, V’ = Ig(G + 2R). Thus, on solving we get V' < 2V

2. (C) 250 µT

Explanation: The magnetic field at the center of a coil of radius R having N turns carrying current I is

$$B_o = \frac{\mu_o N I}{2R}$$

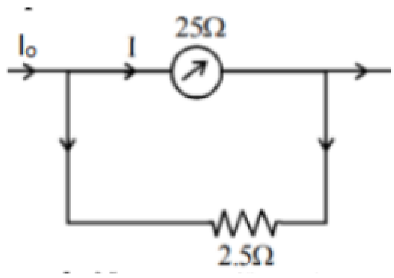
At a point distance x from the coil, the field is $B_x = \frac{NIR^2\mu_o}{2(R^2+x^2)^{\frac{3}{2}}}$

$$\frac{B_o}{B_x} = \frac{(R^2+x^2)^{\frac{3}{2}}}{R^3} = \frac{(3^2+4^2)^{\frac{3}{2}}}{3^3} = \left(\frac{5}{3}\right)^3$$

Thus magnetic field at the center of loop is given by $B_o = \left(\frac{5}{3}\right)^3$ x $54\mu T = 250\mu T$

3. (c) $\frac{I}{I_o} = \frac{1}{11}$

   Explanation:



$$I = \frac{I_o x\ 2.5}{(25+2.5)} = I_o\ X\ \frac{25}{275} = \frac{1}{11}\ X\ I_o$$

Thus $\frac{I}{I_o} = \frac{1}{11}$

4. (a) the electron velocity will decrease in magnitude

   Explanation: The force experienced by an electron in a combined action of magnetic and electric fields is
   $\vec{F} = -e\left(\vec{v} \text{ x } \vec{B} + \vec{E}\right)$.
   Since the electron moves in the same direction of the magnetic field, it experiences no force due to the magnetic field.

$$-e\left(\vec{v}\ X\ \vec{B}\right) = 0.$$

   The electron is not deflected from its straight line path. The total force on the electron, F = — e (E$\hat{j}$). It experiences a force opposite to the direction of the electric field and to its direction of motion. The electron suffers retardation and its velocity decreases.

5. (d) 10^{-17} μo.

   Explanation: $I = \frac{q}{t} = q\ X\ frequency$

   Now, q=100e = 1.6 x 10^{-17} C

   So, I = 1.6 x 10^{-17} X 1 = 1.6 X 10^{-17} A

   Given: r = 0.8 m

   Thus, magnetic field is $B = \frac{\mu_o I}{2r} = 10^{-17}\mu_o$

6. (c) 1.25 x 10^{-5} T

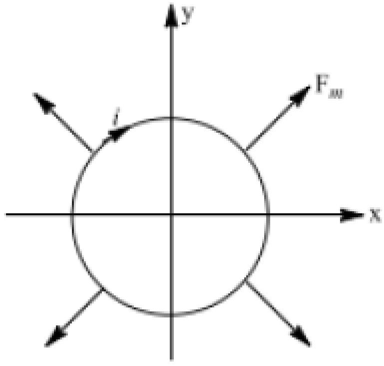
   Explanation: $B = \frac{\mu_o I}{2r} = \frac{4\pi\ X\ 10^{-17}\ X\ 1}{0.1} = 12.56\ X\ 10^{-6} = 1.25\ X\ 10^{-5}\ T$

7. (c) iLB

   Explanation: Magnitude of the Force experienced by a current carrying conductor placed in a magnetic field is I L B sinØ.

   If the angle between the directions of the current and the magnetic field is 90°, F = iLB
8. (b)

   Net force on a current carrying loop in uniform magnetic field is zero. Hence the loop can't translate. So, options (c) and (d) are wrong. From Fleming's left hand rule we can see that if magnetic field is perpendicular to paper inwards and current in the loop is clockwise (as shown) the magnetic force Fm on each element of the loop is radially outwards, or the loops will have a tendency to expand.



9. (a)

$$L = n_1\, 2\pi r_1 = \; n_1\, 2\pi r_1$$
$$\Longrightarrow n_1 r_1 = n_2 r_2 \Rightarrow \frac{r_1}{r_2} = \frac{n_2}{n_1}$$
$$B = \frac{\mu_o n\, i}{2r} \Rightarrow \frac{B_1}{B_2} = \frac{r_2}{r_1} . \frac{n_1}{n_2} = \left(\frac{n_1}{n_2}\right)^2 = \frac{1}{4}$$

10. (a)
11. (c)

   Given, ig = I, G = R_o ;
   I = n i + i = (n+1) i
   Therefore, $S = \frac{i_g\, G}{i - i_g} = \frac{iR_o}{(n+1)i - i} = \frac{R_o}{n}$
12. (b) $F = Bil$ 2 x 1.2 x 0.5 = 1.2 N
13. (b)

   Direction of magnetic field at every point on axis of a current carrying coil remains same though magnitude varies. Hence, magnetic induction for whole of the X-axis will remain positive. Therefore, (c) and (d) are wrong
   Magnitude of magnetic field will vary with x according to the formula

$$B = \frac{\mu_o N\, i\, R^2}{2(R^2 + x^2)^{\frac{3}{2}}}$$

   Hence, at x = 0, $B = \frac{\mu_o N\, i}{2R}$ $and\ when\ x \to \infty, B \to 0$

   Slope of the graph will be $\frac{dB}{dx} = -\frac{3\mu_o N\, i\, R^2}{2\,(R^2+x^2)^{\frac{5}{2}}} x$

   It means, at x = 0, slope is equal to zero or tangent to the graph at x = 0, must be parallel to X-axis.

14. (b)

$$r = \sqrt{\frac{2\,m_1 E_{k1}}{B\,q_1}} = \sqrt{\frac{2\,m_2\,E_{k2}}{B\,q_2}}$$

$$or\ E_{k2} = \frac{m_1 q_2}{m_2 q_1} E_{k1} = 100keV$$

15. (a) $r_1: r_2 = 1:2$ and $B_1: B_2 = 1:3$, we know that

$$B = \frac{\mu_o\,2\pi\,n\,i}{4\pi\,r} \Rightarrow \frac{i_1}{i_2} = \frac{B_1 r_1}{B_2 r_2} = 1/6$$

16. (b) Use Right hand palm rule or Maxwell's Cork screw rule

17. (a)

18. (d) In the following figure magnetic field at the midpoint M is given by

$$B_{net} = B_Q - B_P$$

$$= \frac{\mu_o 2}{4\pi r}(i_Q - i_P) = \frac{\mu_o}{2\pi}$$

19. (c) Length of the component dl which is parallel to wire (1) is dl cosθ, so force on it

$$F = \frac{\mu_o}{4\pi}\frac{2 i_1 i_2}{r}\ (\,dl\ cos\theta)$$

20. (b)

Explanation: In the absence of magnetic field $mg = 2kx_o$--- (i)

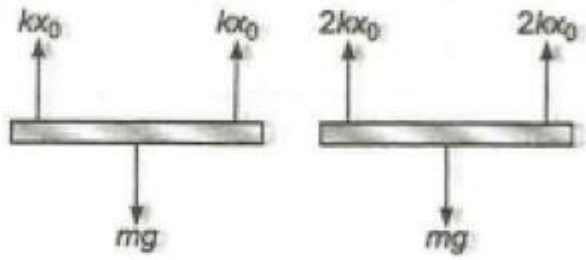
The current in the rod is $i = E/R$

Magnetic force on the rod is $F_m = BiL = \frac{ELB}{R}$

In downward direction $2kx_o = mg + \frac{BLE}{LE}\quad --(ii)$

$$from\ Eqs. (i)\ and\ (ii)\ we\ get\ 4kx_o = 2kx_o + \frac{BLE}{R}$$

$$B = \frac{2kx_o R}{EL} = \frac{mgR}{LE}$$



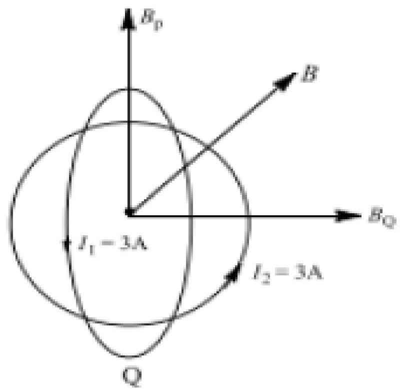
21. (c)

Explanation:

$$B_P = \frac{\mu_o I_2}{2R} = \frac{4\pi\ x\ 10^{-7} x\ 4}{2\ x\ 0.02\pi} = 4\ x\ 10^{-5}\ Wbm^{-2}$$

$$B_Q = \frac{\mu_o I_1}{2R} = \frac{4\pi\ x\ 10^{-7} x\ 3}{2\ x\ 0.02\pi} = 3\ x\ 10^{-5}\ Wbm^{-2}$$

$$B = \sqrt{B_P^2 + B_Q^2} = 5\ x\ 10^{-5}\ Wbm^{-2}$$



22. (b)

From Biot-Savart's law the magnetic field (B) due to a conductor carrying current I, at a distance r_1 is $B_1 = \frac{\mu_o I_1}{2\pi r_1}$

Magnetic field at P due to current in second conductor is $B_2 = \frac{\mu_o I_2}{2\pi\,(r_1+d)}$

From Fleming's right hand rule the fields at P are directed opposite.

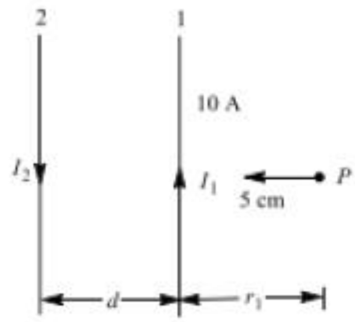
Therefore Resultant field $B_1 = B_2$

$$\therefore \quad \frac{\mu_0 I_1}{2\pi r_1} = \frac{\mu_0 I_2}{2\pi(r_1 + d)}$$

Given, $I_1 = 10$ A, $r_1 = 5, r_1 + d = 5 + 10 = 15$ cm

$$\therefore \quad I_2 = \frac{I_1}{r_1} \times (r_1 + d)$$

$$I_2 = \frac{10}{5} \times 15 = 30 \text{ A}$$



23. (d) Use Right hand palm rule, or Maxwell's Cork Screw rule or any other.

24. (c)

$$Force, F = B\ i\ l\ sin\theta$$

$$F = 500\ x\ 10^{-4}\ x\ 3\ x\ 40\ x\ 10^{-2}\ x\ \frac{1}{2}$$

$$F = 3\ x\ 10^{-2}\ N$$

25. (c)

$$B_0 = B_{PQ} + B_{QR} + B_{RO}$$
$$= \frac{\mu_0}{2\pi}\frac{i}{r} + \frac{\mu_0 (1/2) i}{2\pi} + 0$$
$$= \frac{\mu_0}{4\pi}\frac{2i}{r} + \frac{\mu_0}{4\pi}\frac{\pi i}{r} = \frac{\mu_0}{4\pi}\frac{i}{r}(2+\pi)$$

26. (d) $\tau = NiBA \propto A$

For given periphery circle has maximum area.

27. (d)

$$F = \frac{\mu_0}{4\pi}\frac{2l^2}{a}$$
$$F_1 = \frac{\mu_0}{4\pi}.\frac{2i^2}{x} \quad \text{[Attraction]}$$
$$F_2 = \frac{\mu_0}{4\pi}\frac{2i \times 2i}{2x} = \frac{\mu_0}{4\pi}\frac{2i_2}{x} \quad \text{[Repulsion]}$$
Thus $F_1 = -F_2$

28. (c)

Potential difference across C and D = 10 V. If x is the resistance of ammeter, than

X+ R = 10/2 = 5 or R = 5- X $< 5\Omega$

29. (a)

Since, the magnetic field does not perform any work, therefore, whatever has been gain in kinetic energy it is only because of the work done by electric field. Applying work – energy theorem

$$W = \Delta E$$
$$qE_o = \frac{1}{2} m v^2 - 0$$
$$or\ v = \sqrt{\frac{2qE_o}{m}}$$

30. D Assertion statement is false and Reason statement is true

31. B Both the statements are true but doesn't explains the assertion

32. A Both statements are correct and Statement 2 is correct explanation to Statement 1

33. C Statement 1 is correct but statement 2 is false.

34. 1-a, 2-b, 3-d, 4-b, 5-d

35. 1-a, 2-d, 3-a, 4-d, 5-a

36. (b) 0.36J/T

Explanation: Torque, τ = M B sinθ, where M is magnetic moment, B is magnetic field and θ is angle between magnetic moment and magnetic field.

$$4.5\ x\ 10^{-2} = 0.25\ x\ m\ x\ 0.5$$
$$M = \frac{9}{25} = 0.36\frac{J}{T}$$

37. (A) $\oint \vec{B}\,.\overrightarrow{ds} = 0$

Explanation: since magnetic monopoles do not exist. Flux entering the closed surface is equal to flux leaving the surface. Hence, net magnetic flux through a closed surface is zero.

38. (a) F

Explanation: $F \propto \frac{q_m q'_m}{r^2}$

$$hence\ \frac{F'}{F} = \left(\frac{2q_m q'_m}{4r^2}\right) \Big/ \left(\frac{q_m q'_m}{r^2}\right) = 1$$

$$or\ F = F'$$

39. (c) Equal to zero

40. (a)

On axial position

$$B_a = \frac{\mu o}{4\pi} \frac{2Mr}{(r^2 - l^2)^2}\ if \ll r, then\ B_a = \frac{\mu o}{4\pi} \frac{2M}{R^3}$$

$$B_a = \frac{\mu o}{4\pi} \frac{2\ s\ 1.2}{(0.1)^3} = 2.4\ x\ 10^{-4}\ T$$

41. 0.001 T

Explanation: m = M / volume = $\frac{4\ x\ 10^{-5}}{8\ x\ 10^{-6}} = 5\ Am^2$

Along axis, magnetic field is given by,

$$B = \frac{\mu_o}{4\pi} \frac{2m}{r^3} = 10^{-7}\ x\ \frac{2\ x\ 5}{10^{-6}} = 10^{-3}\ T = 0.001T$$

42. (c)1.28 A m^2

Explanation: m = NIA

m = 2000 x 1.6 x 10^{-4} x 4 = 1.28 Am^2.

43. (b) 2/3 Am^{-1}

Explanation: On increasing the temperature magnetic susceptibility of paramagnetic material decreases or vice versa. According to Curie law, we can deduce a formula for the relation between magnetic field induction, temperature and magnetization.

$$I\ (magnetisation) \propto \frac{B\ (magnetic\ field)}{T(temperature)} \Rightarrow \frac{I_2}{I_1} = \frac{B_2}{B_1} X \frac{T_1}{T_2}$$

$$here\ \frac{I_2}{8} = \frac{0.2}{0.6} X \frac{4}{16} \Rightarrow I_2 = \frac{2}{3}\ Am^{-1}$$

44. (a)

Explanation: Since torque is cross product of magnetic moment vector and area vector given by $\vec{M}$ x $\vec{B}$

45. (c) $\varepsilon_r = 1.5, \mu_r = 0.5$

Explanation: For a diamagnetic material, relative permittivity is greater than 1 and relative permeability is less than 1.

46. (c) 0.01Am : Explanation: Pole strength = M x A = 100 A/m x 10^{-4} m^2 = 10^{-2} Am.

47. (d) 0.48 G along N-S direction

Explanation: $\vec{B} = \frac{\mu_o}{4\pi} \frac{\vec{m}}{r^3} = 10^7 x\ \frac{0.48}{10^{-3}} = 0.48\ x\ 10^{-4} T = 0.48\ G$

Direction of magnetic field at equatorial position is opposite to that of the magnetic moment direction

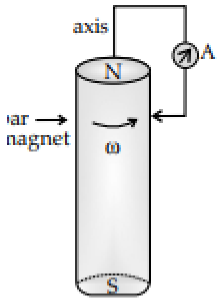
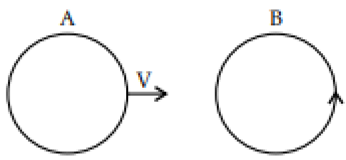
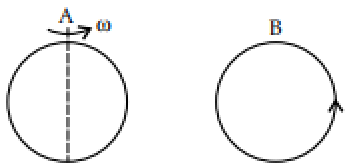
48. (b) Explanation: Both statements are true but statement 2 not explaining the statement 1

49. (c) Statement 1 is true and statement 2 is false

50. 1-c, 2-a, 3-c, 4-c, 5-a.

UNIT-IV- ELECTROMAGNETIC INDUCTION & ALTERNATING CURRENT

MCQs on EMI

1	A square of side L meters lies in the x-y plane in a region where the magnetic field is given by $B = B_o(2i + 3j + 4k)$ tesla, where B_o is constant. The magnitude of flux passing through the square is (A) $2B_oL^2$ Wb (B) $3B_oL^2$ Wb (C) $4B_oL^2$Wb (D) $\sqrt{29}B_o L^2$Wb
2	A cylindrical bar magnet is rotated about its axis in the figure.  A wire is connected from the axis and is made to touch the cylindrical surface through a contact. Then (A) a direct current flows in the ammeter A. (B) no current flows through the ammeter A. (C) an alternating sinusoidal current flows through the ammeter A with a time period $2\pi/\omega$. (D) a time varying non-sinusoidal current flows through the ammeter A
3	There are two coils A and B as shown in figure. A current starts flowing in B as shown, when A is moved towards B and stops when A stops moving. The current in A is counter clockwise. B is kept stationary when A moves. We can infer that  (A) There is a constant current in the clockwise direction in A. (B) There is a varying current in A. (C) There is no current in A. (D) there is a constant current in the counter clockwise direction in A
4	Same as problem 4 except the coil A is made to rotate about a vertical axis figure. No current flows in B if A is at rest. The current in coil A, when the current in B (at t = 0) is counter-clockwise and the coil A is as shown at this instant, t = 0, is  (A) Constant current clockwise. (B) Varying current clockwise. (C) Varying current counter-clockwise. (D) Constant current counter-clockwise.
5	The polarity of induced emf is defined by (A) Ampere's circuital law (B) Biot-Savart's law (C) Lenz's law (D) Fleming's right hand rule

6	Lenz's law is consequence of the law of conservation of (A) charge (B) mass (C) energy (D) momentum
7	The magnetic flux linked with a coil is given by an equation $\varphi = 5t^2 + 2t + 3$. The induced e.m.f. in the coil at the third second will be (A) 32 units (B) 54 units (C) 40 units (D) 65 units
8	The self-inductance L of a solenoid of length l and area of cross-section A, with a fixed number of turns N increases as (A) l and A increase (B) l decreases and A increases (C) l increases and A decreases (D) both l and A decrease
9	If the back e.m.f. induced in a coil, when current changes from 1A to zero in one millisecond, is 5 volts, the self-inductance of the coil is (A) 5 H (B) 1 H (C) 5×10^{-3} H (D) 5×10^{3} H
10	An inductor and a bulb are connected in series with a dc source. A soft iron core is then inserted in the inductor. What will happen to intensity of the bulb? (A) Intensity of the bulb remains the same (B) Intensity of the bulb decreases (C) Intensity of the bulb increases (D) The bulb ceases to glow

KEY (EMI) : **1-C, 2-B, 3-D, 4-A, 5-C, 6-C, 7-A, 8-B, 9-C, 10-B**

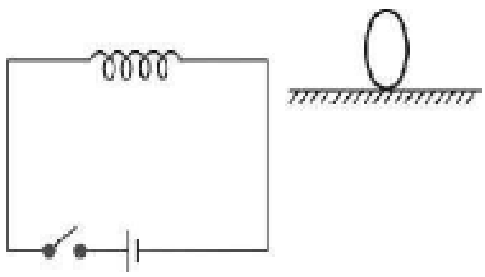
Explanations:

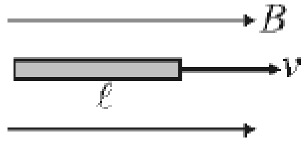
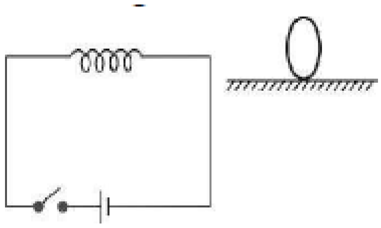
1	Magnetic flux is defined as the total number of magnetic lines of force passing normally through an area placed in a magnetic field and is equal to the magnetic flux linked with that area. ϕ = B.A, B_o (2i+ 3j+ 4k). L^2K=) $4B_oL^2$
2	Explanation: The phenomenon of electromagnetic induction is used in this problem. Whenever the number of magnetic lines of force (magnetic flux) passing through a circuit changes (or a moving conductor cuts the magnetic flux), an emf is produced in the circuit (or emf induces across the ends of the conductor) is called induced emf. The induced emf persists only as long as there is a change or cutting of flux. When cylindrical bar magnet is rotated about its axis, no change in flux linked with the circuit takes place, consequently no emf induces and hence, no current flows through the ammeter A. Hence the ammeter shows no deflection.
3	When coil A moves towards coil B with constant velocity, so rate of change of magnetic flux due to coil B in coil A will be constant that gives constant current in coil A in same direction as in coil B by Lenz's law.
4	In this case, the direction of the induced electromotive force/induced current is determined by the Lenz's law. According to the Lenz's law, the direction of induced emf or current in a circuit is such that it oppose x the cause that produces it. This law is based upon law of conservation of energy. When the current in coil B (at t = 0) is counterclockwise and the coil A is considered above it. The counter-clockwise flow of the current in coil B is equivalent to North Pole of magnet and magnetic field lines are eliminating upward to coil A. When coil A starts rotating at t = 0, the current in coil A is constant along clockwise direction by Lenz's rule.
5	According to Lenz's law, the direction of an induced e.m.f. always opposes the change in magnetic flux that causes the e.m.f
6	Lenz's law is a consequence of the law of conservation of energy. Lenz's law says that induced current always tends to oppose the cause which produces it. So work is done against

	opposing force. This work is transformed into electrical energy. So, it is a consequence of law of conservation of energy.
7	Induced e.m.f = – (dφ /dt)= (5t ^{2} + 2t + 3) = – (10t + 2) = – 32 units
8	As we know that As L is constant for a coil, L αA and $L = \mu_r \mu_0 \frac{N^2 A}{l}$ and N are constant here so, to increase L for a coil, area A must be increased and l must be decreased.
9	$e = -L\frac{di}{dt}$, 5 = $-L(\frac{0-1}{10^{-3}})$, L = 5 × 10^{-3} H
10	When a soft iron core is inserted in the inductor, the magnetic flux increases. According to Lenz's law, it will be resisted by reducing the current. Since the current reduces, the intensity of the bulb decreases.

ASSERTION-REASON TYPE QUESTIONS (EMI)

Directions: In the following questions, a statement of assertion is followed by a statement of reason.
Mark the correct choice as:
(A) Both Assertion and reason are true and reason is correct explanation of assertion.
(B) Assertion and reason both are true but reason is not the correct explanation of assertion.
(C) Assertion is true, reason is false.
(D) Assertion is false, reason is true.

Sl.No.	Question	Learning Objective
1	Assertion : Induced emf will always occur whenever there is change in magnetic flux. Reason : Current always induces whenever there is change in magnetic flux.	Knowledge
2	Assertion : An induced current has a direction such that the magnetic field due to the current opposes the change in the magnetic flux that induces the current. Reason: Above statement is in accordance with conservation of energy.	Analysis
3	Assertion: Acceleration of a magnet falling through a long solenoid decreases. Reason :The induced current produced in a circuit always flow in such direction that it opposes the change to the cause that produced it.	Application
4	Assertion: Figure shows a horizontal solenoid connected to a battery and a switch. A copper ring is placed on a smooth surface, the axis of the ring being horizontal. As the switch is closed, the ring will move away from the solenoid.  Reason : Induced emf in the ring, e = - dΦ/dt	Application

5	Assertion : Figure shows a metallic conductor moving in magnetic field. The induced emf across its ends is zero.  Reason: The induced emf across the ends of a conductor is given by $e = Bv\ell \sin\theta$.	Understanding
6	Assertion : Eddy currents are produced in any metallic conductor when magnetic flux is changed around it. Reason : Electric potential determines the flow of charge.	Knowledge
7	Assertion : When number of turns in a coil is doubled, coefficient of self-inductance of the coil becomes 4 times. Reason : This is because $L \propto N^2$.	Creative
8	Assertion : Only a change in magnetic flux will maintain an induced current in the coil. Reason : The presence of large magnetic flux through a coil maintain a current in the coil of the circuit is continuous.	Application
9	Assertion : The induced e.m.f. and current will be same in two identical loops of copper and aluminium, when rotated with same speed in the same magnetic field. Reason : Induced e.m.f. is proportional to rate of change of magnetic field while induced current depends on resistance of wire.	Understanding
10	Assertion : Self-inductance is called the inertia of electricity. Reason : Self-inductance is the phenomenon, according to which an opposing induced e.m.f. is produced in a coil as a result of change in current or magnetic flux linked in the coil.	Knowledge
11	Assertion : Figure shows a horizontal solenoid connected to a battery and a switch. A copper ring is placed on a smooth surface, the axis of the ring being horizontal. As the switch is closed, the ring will move away from the solenoid.  Reason : Induced emf in the ring, $e = - d\Phi/dt$	knowledge
12	Assertion : An emf can be induced by moving a conductor in a magnetic field. Reason : An emf can be induced by changing the magnetic field.	knowledge
13	Assertion- Faraday laws are consequence of conservation of energy. Reason - In a purely resistive AC circuit, the current lags behind the emf in phase.	analysis
14	Assertion-- The mutual induction of two coils is doubled, if the self-inductance of the primary or secondary coil is doubled. Reason -- Mutual induction is proportional to self-inductance of primary and secondary coils	analysis
15	Assertion- Eddy current is produced in any metallic conductor when magnetic flux is changed around it. Reason -- Electric potential determine the flow of charge.	application

ANSWERS (EMI- Assertion-Reason Questions)

Assertion Reason Questions	
Q.No.	Answers
1	(C) Assertion is true, reason is false.
2	(B) Assertion and reason both are true but reason is not the correct explanation of assertion.
3	(A) Both Assertion and reason are true and reason is correct explanation of assertion.
4	(A) Both Assertion and reason are true and reason is correct explanation of assertion.
5	(A) Both Assertion and reason are true and reason is correct explanation of assertion.
6	(B) Assertion and reason both are true but reason is not the correct explanation of assertion.
7	(B) Assertion and reason both are true but reason is not the correct explanation of assertion.
8	(C) Assertion is true, reason is false.
9	(D) Assertion is false, reason is true.
10	(B) Assertion and reason both are true but reason is not the correct explanation of assertion.
11	(A) Both Assertion and reason are true and reason is correct explanation of assertion.
12	(B) Assertion and reason both are true but reason is not the correct explanation of assertion.
13	(C) Assertion is true, reason is false.
14	(C) Assertion is true, reason is false.
15	(B) Assertion and reason both are true but reason is not the correct explanation of assertion.

MCQs on Alternating Current

1	When frequency of applied alternating voltage very high then (A) A capacitor will tend to become SHORT (B) An inductor will tend to become SHORT (C) Both (A) and (B) (D) No one will become short
2	With increase in frequency of an A.C. supply, the impedance of a series L-C-R circuit (A) remains constant (B) increases. (C) decreases (D) decreases at first, becomes minimum and then increases
3	An A.C. source is connected to a resistive circuit. Which of the following statements is true? (A) Current leads the voltage in phase (B) Current lags the voltage in phase (C) Current and voltage are in same phase (D) Either (A) or (B) depending on the value of resistance
4	To reduce the resonant frequency in an L-C-R series circuit with a generator (A) the generator frequency should be reduced. (B) another capacitor should be added in parallel to the first. (C) the iron core of the inductor should be removed. (D) dielectric in the capacitor should be removed.
5	At resonance, the impedance in series LCR circuit is (A) maximum (B) zero (C) infinity (D) minimum
6	The efficiency of transformer is very high because (A) There is no moving part (B) It uses AC only (C) It uses the copper wire for the coils (D) None of the above

7	_______ increases in step-down transformer. (A) Voltage (B) Current (C) Power (D) Current density
8	Quantity that remains unchanged in a transformer is (A) voltage (B) current (C) frequency (D) none of these
9	If rotational velocity of an armature is doubled, emf generated in a generator will be (A) half (B) two times (C) four times (D) unchanged
10	The core of a transformer is laminated as (A) it improves the ratio of voltage in the primary and secondary may be increased (B) it checks rusting of the core may be stopped (C) it reduces energy losses due to eddy currents (D) it increases flux linkage

Key (MCQs on AC) : **1 –A, 2-D, 3-A, 4-B, 5-D, 6-A, 7-B, 8-C, 9-B, 10-C**

Explanations

1	$X_C = 1/2\pi fC$ So, as f increases, X_C becomes smaller and smaller. For very high value of f, X_C will be too small which may be considered as SHORT.
2	The frequency-impedance graph of a series LCR circuit with increase in frequency, the impedance decreases at first, becomes minimum and then increases.
3	In a pure resistive circuit, current and voltage are always in phase
4	The resonant frequency of L-C-R series circuit is $\frac{1}{2\pi\sqrt{LC}}$. So to reduce resonant frequency, we have either to increase L or to increase C. To increase capacitance, another capacitor must be connected in parallel with the first.
5	Impedance of a series LCR circuit is $Z = \sqrt{R^2 + (X_L - X_C)^2}$ At resonance, $X_C = X_L$. So, Z is minimum.
6	Transformer is a static device which transforms power from one circuit to other through electromagnetic induction. In electrical transformer as there are no moving parts, no friction. Losses in the transformer are very less compared to any other rotating machine, hence efficiency of transformers will be very high which about 95% to 98% is.
7	Since $V_P/V_S = I_S/I_P$, so as as voltage reduces, the current increases in a step-down transformer
8	Transformer does not change the frequency of the applied AC.
9	emf generated = $NBA\omega \sin\omega t$, as ω becomes double, emf generated also becomes double.
10	Laminated core means a layered core instead of a single solid core. Eddy currents are current loops generated by changing magnetic fields. They flow in a plane perpendicular to the magnetic field. Laminated magnetic core reduces eddy currents. For this reason, electrically isolated laminations are utilized to manufacture transformers

ASSERTION - REASON questions on Alternating Current

Directions : In the following questions, A statement of Assertion (A) is followed by a statement of Reason (R). Mark the correct choice as.

(A) Both A and R are true and R is the correct explanation of A
(B) Both A and R are true but R is NOT the correct explanation of A
(C) A is true but R is false
(D) A is false and R is true

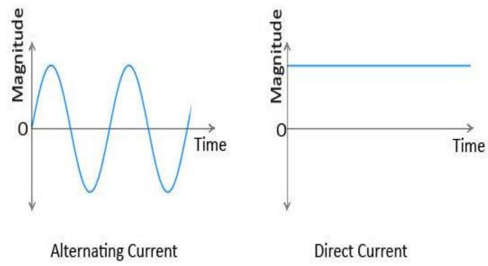
1	Assertion (A): An alternating current does not show any magnetic effect. Reason (R): Alternating current changes direction with time.
2	Assertion (A): Capacitor blocks dc and allows ac to pass. Reason (R): Capacitive reactance is inversely proportional to frequency.
3	Assertion (A): Both ac and dc can be measured by hot wire instrument. Reason (R): Hot wire instrument is based on the principal of magnetic effect of current.
4	Assertion (A): At resonance, the current becomes minimum in a series LCR circuit. Reason (R): At resonance, voltage and current are out of phase in a series LCR circuit
5	Assertion (A): V_{rms} value of an alternating voltage V = 4 $\sqrt{2}$ sin 314t is 4 volt. Reason (R): Peak value of the alternating voltage is 4 $\sqrt{2}$ volt.
6	Assertion (A): When capacitive reactance is less than the inductive reactance in a series LCR circuit, e.m.f. leads the current. Reason (R): The angle by which alternating voltage leads the alternating current in series RLC circuit is given by.$\tan\phi = \frac{X_{L-}X_C}{R}$
7	Assertion (A): A transformer does not work on DC. Reason (R): DC neither change direction nor magnitude.
8	Assertion (A): An alternator is a machine which converts mechanical energy into electrical energy. Reason (R): When a coil rotates in a magnetic field an e.m.f. is induced in it.
9	Assertion (A): Principle of operation of AC generator is electromagnetic induction. Reason (R): Resistance offered by inductor for AC is zero.
10	Assertion (A): A step-up transformer converts input low AC voltage to output high AC voltage. Reason (R): It violates the law of conservation of energy.
KEY	**: 1-D, 2-A, 3-C, 4-D, 5-B, 6 –A, 7-A, 8-A, 9-B, 10-C**

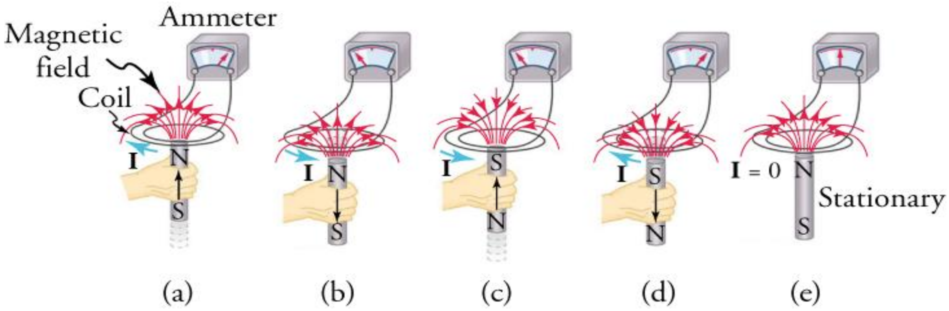
EXPLANATIONS

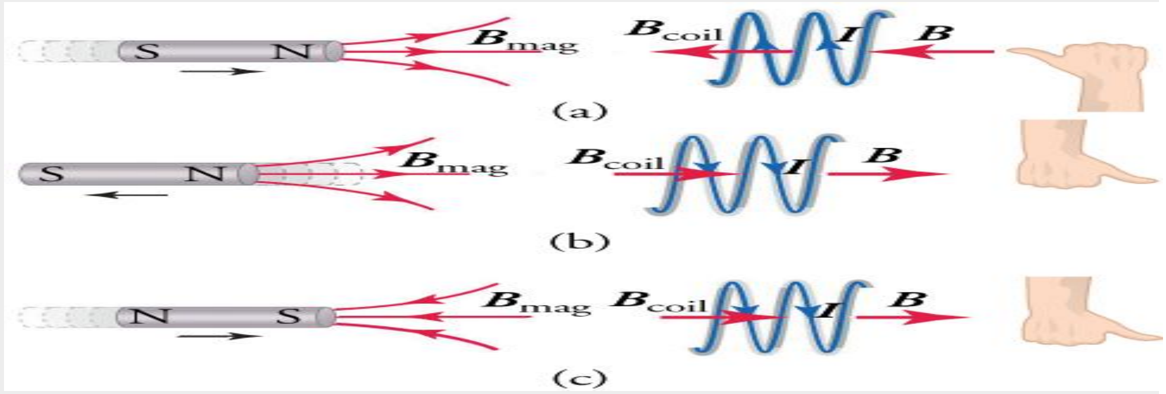
1	Explanation: Current or moving charged particle creates magnetic field irrespective of direct current or alternating current. So assertion is false. Alternating current changes direction with time. So, the reason is true, but cannot explain the assertion
2	Capacitive reactance = 1/ 2πfC, So, as f (frequency) increases, reactance decreases. For dc, frequency = 0, hence capacitor offers infinite reactance. So, it blocks dc. For ac, frequency ≠ 0, hence capacitor offers low reactance and allows ac to pass. Hence assertion and reason both are true. Assertion is properly explained by reason.
3	Explanation: In both ac and dc, heat generated is proportional to the square of current. Polarity change of ac is immaterial in the case of heat generation. Hence they can be

	measured by hot wire instrument. Hence, the assertion is true. Hot wire instruments are based on the principle of heating effect of current. Hence the reason is false.
4	At resonance, $X_L = X_C$, so the circuit impedance becomes minimum and resistive and hence the current becomes maximum. So, the assertion is false. At resonance, $X_L = X_C$, so the circuit impedance becomes resistive. In resistive circuit voltage and current are always in same phase. Hence, reason is also false
5	Given alternating voltage $V = 4\sqrt{2}\sin 314t$. Where peak value $= V_o = 4\sqrt{2}$ volt. $V_{rms} = V_o/\sqrt{2} = 4$ volt. Hence both assertion and reason both are true. But the reason does not properly explain the assertion.
6	The angle by which alternating voltage leads the alternating current in series RLC circuit is given by $\tan\phi = \frac{X_L - X_C}{R}$. If $X_C < X_L$, then tan j is positive. J is also positive. So, e.m.f. leads the current. Assertion and reason both are true. Reason properly explains the assertion
7	Transformer has two coils. If current fluctuates in one coil, e.m.f. is induced in the other coil. For DC supply current does not change, so there is no induced e.m.f. Hence both assertion and reason are true and reason explains the assertion.
8	Alternator is basically a generator in which a coil rotates in a strong magnetic field and according to laws of electromagnetic induction e.m.f. is generated. So, assertion and reason both are true and reason explains the assertion.
9	Principle of operation of AC generator is electromagnetic induction. The assertion is true. Resistance offered by inductor = $2\pi fL$. For AC, $f \neq 0$. So, $2\pi fL \neq 0$. So, the reason is false.
10	Step-up transformer means it converts input low AC voltage to output high AC voltage. So, the assertion is true. For step up transformer, $V_{OUT} / V_{IN} > 1$, but simultaneously $I_{OUT} / I_{IN} < 1$ and $P_{IN} = P_{OUT}$ (ideally). Hence, the law of conservation of energy is not violated.

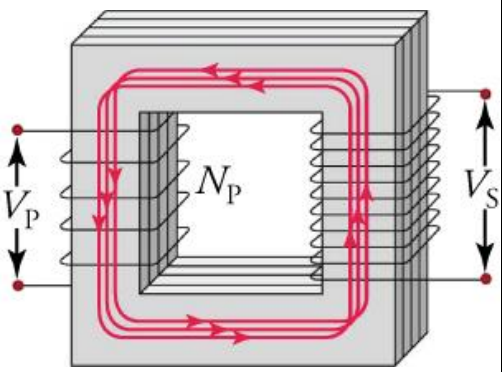
CASE STUDY TYPE QUESTIONS on EMI & AC

CASE STUDY-1	Alternating Current (AC) is one of the two types of electric current (AC and DC). In alternating current, the direction of the electrons switches back and forth at regular intervals. This is the most common type of electric current. The current flowing through the power lines to our homes is an alternating current. The circuits powered by alternating currents are called AC circuits. Alternating currents produce a sinusoidal wave whereas a Direct Current (DC) current has a constant magnitude and hence plots a straight line. 
1	Which one of the following doesn't have amplitude? a) AC voltage b) DC voltage c) Both a and b d) None of the above
2	In India the electricity standards are ______________ a) 30 volts and 50 hertz b) 20 volts and 50 hertz c) 230 volts and 50 hertz d) 10 volts and 50 hertz
3	What is the potential difference between a live wire and neutral wire? a) 180 V b)220 V c) 320 V d)250 V

4	An alternating current can be produced by a) Choke Coil b) Dynamo c) Electric Motor d) Transformer
5	The frequency of an alternating current is a) The speed with which the alternator runs b) The number of cycles generated in one minute c) The number of waves passing through a point in one second d) The number of electrons passing through a point in one second
KEY	**1-b, 2-c, 3-b, 4-b, 5-c**
Explanation	1 (b) DC voltage doesn't have amplitude 2 (c) 230 volts and 50 hertz 3(b) Potential difference can be expressed as the difference between two points in a circuit in the amount of energy which the charge carriers have. The potential difference between live wire and neutral wire is 220 V. An electric fuse is usually located in the phase wire's path before it is attached to the electric meter. 4(b) Dynamo 5(c) The number of waves passing through a point in one second.
CASE STUDY-2	One experiment Faraday did to demonstrate magnetic induction was to move a bar magnet through a wire coil and measure the resulting electric current through the wire. A schematic of this experiment is shown in fig. He found that current is induced only when the magnet moves with respect to the coil. When the magnet is motionless with respect to the coil, no current is induced in the coil, as in fig In addition, moving the magnet in the opposite direction or reversing the poles of the magnet results in a current in the opposite direction. 
1	Which of the following factors is the induced charge in an electromagnetic induction independent of? a) Time b) Resistance of the coil c) Change of flux d) None of the above
2	Which of the following states that an emf is induced whenever there is a change in the magnetic field linked with electric circuits? a) Lenz's Law b)Ohm's Law c) Faraday's Law of Electromagnetic Induction d)None of the above
3	Electrical Inertia is the measure of a)Self Inductance b)Mutual Inductance c)Impedance d)None of the above
4	Which of the following laws is the consequence of the Law of conservation of energy? a) Lenz's Law b) Ohm's Law c) Kirchhoff's law d) All of the above
5	Which of the following apparatus construction uses electromagnetic induction? a) Voltmeter b) Galvanometer c) Generator d) Electric Motor

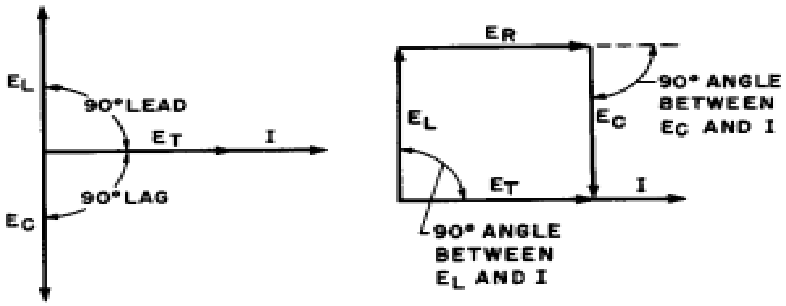
KEY	1-(a) Time 2-(c) Faraday's Law of Electromagnetic Induction 3-(a) Self Inductance 4-(a) Lenz's Law 5-(c) Generator
Explanation	1-(a) The induced charge in an electromagnetic induction is independent of time. 2-(c) Faraday's Law of Electromagnetic Induction states that an emf is induced whenever there is a change in the magnetic field linked with the electric circuit's changes. 3 (a) Electrical Inertia is the measure of self-inductance 4-(a) Lenz's Law is the consequence of the Law of conservation of energy.. 5-(c) The construction of the generator uses the principle of electromagnetic induction.
CASE STUDY-3	Faraday's Electromagnetic Lab Play with a bar magnet and coils to learn about Faraday's law. Move a bar magnet near one or two coils to make a light bulb glow. View the magnetic field lines. A meter shows the direction and magnitude of the current. View the magnetic field lines or use a meter to show the direction and magnitude of the current. You can also play with electromagnets, generators and transformers! Orient the bar magnet with the north pole facing to the right and place the pickup coil to the right of the bar magnet. Now move the bar magnet toward the coil and observe in which way the electrons move. This is the same situation as depicted below. Does the current in the simulation flow in the same direction as shown below? Explain why or why not. 
1	Which of the following rules is used to identify the direction of the current induced in a wire moving in a magnetic field? a) Ampere's Rule b) Fleming's Left-Hand Rule c) Fleming's Right-Hand Rule d) None of the above
2	When an insulated wire coil is connected to a battery, the pointer of the galvanometer is deflected due to: a) the induced current produced b) the coil acts like a magnet c) the number of turns in the coil of the galvanometer is changed d) None of these
3	Polarity of the induced emf is determined by: a) Ampere's circuital law b) Biot–Savart law c) Lenz's law d) Fleming's right-hand rule
4	A magnet is moved towards a coil (i) quickly (ii) slowly, then the induced e.m.f. is (a) larger in case (i) (b) smaller in case (i) (c) equal to both the cases (d) larger or smaller depending upon the radius of the coil

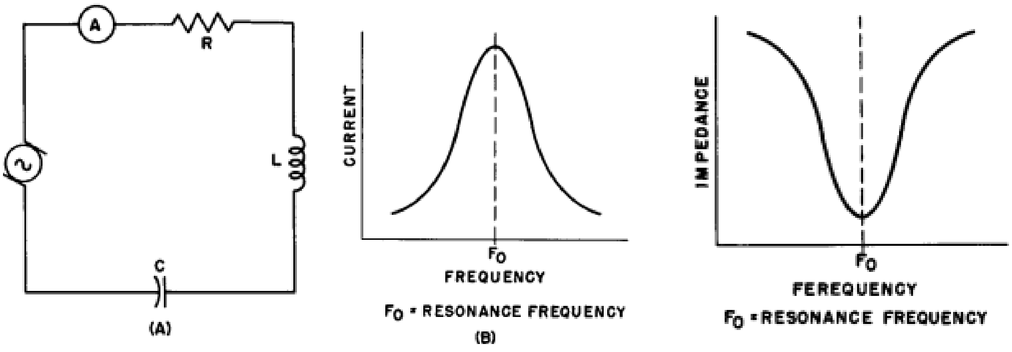
5	Two identical coaxial circular loops carry a current i each circulating in the same direction. If the loops approach each other, you will observe that the current in (a) each increases (b) each decreases (c) each remains the same (d) one increases whereas that in the other decreases
KEY	**1-(c), 2-(a), 3-(c), 4-(a), 5- (b)**
Explanations	1-(c) Fleming's Left Hand Rule is used in identifying the direction of the current induced in a wire moving in a magnetic field. 2-(a) Galvanometer measures the amount of current flowing through the circuit. In a current flowing conductor connected to a battery, the pointer of the galvanometer fluctuates and points to the amount of current flowing. Thus a galvanometer measures the amount of induced current in the circuit. 3-(c) Lenz's law is used to measure the polarity of induced e.m.f. Ampere's law correlates with the magnetic field induced in a coil. Biot–Savart's law describes the magnetic field generated by a constant electric current. Fleming's right-hand rule gives the estimate that in which direction the current will flow. 4-(a) emf is directly proportional to flux linked with the coil. 5-(b) According to faraday law of electromagnetic induction opposing the cause.

CASE STUDY-4	Figure shows a laminated-coil transformer, which is based on Faraday's law of induction and is very similar in construction to the apparatus Faraday used to demonstrate that magnetic fields can generate electric currents. The two wire coils are called the primary and secondary coils. In normal use, the input voltage is applied across the primary coil, and the secondary produces the transformed output voltage. Not only does the iron core trap the magnetic field created by the primary coil, but also its magnetization increases the field strength, which is analogous to how a dielectric increases the electric field strength in a capacitor. Since the input voltage is AC, a time-varying magnetic flux is sent through the secondary coil, inducing an AC output voltage  In figure, A typical construction of a simple transformer has two coils wound on a ferromagnetic core. The magnetic field created by the primary coil is mostly confined to and increased by the core, which transmits it to the secondary coil. Any change in current in the primary coil induces a current in the secondary coil.
1	If the supply frequency (f) of a transformer decreases, the effect of frequency on the transformer's secondary output voltage? a)Remain the same b)Decreases c)Increases d)All of these
2	Lamination of the transformer core is made up of a) Aluminium b) Iron c) Steel d) Silicon steel
3	The transformer ratings are expressed in terms of a) kW (kilo-Watt) b)Volts c) KVAR (kilo-Volt-Ampere-Reactive) d) KVA (kilo-Volt-Ampere)
4	Oil is provided in an oil-filled transformer for a) Lubrication b) Cooling c) Insulation d) Both cooling and Insulation

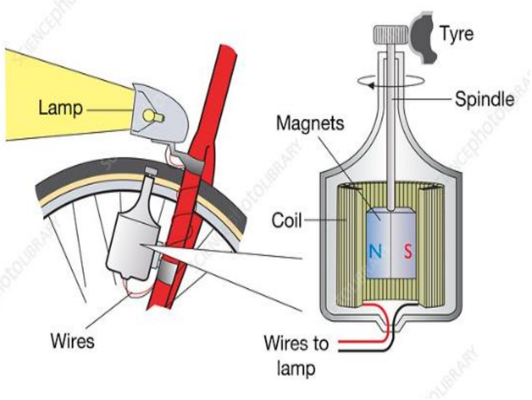
5	Crushed rocks are provided in the substation to a) To avoid growing plants and weeds b) To provide insulation c) To avoid fire accidents during leakage of transformer oil d) All of the above
6	Which quantity is increased in a step-down transformer? (a) Current (b) Voltage (c) Power (d) Frequency
KEY	**1-a, 2 –d, 3-d, 4-d, 5-d, 6-a**
Explanation	1-a) The transformer is a static electromagnetic device that transforms the voltage from one side of its coil to the other side of the coil without a change in frequency. As we know, the working principle of transformer is based on Mutual induction, which happens at a constant frequency. 2-d) A high permeable material made up of thin silicon steel laminations are used for lamination of transformer core and other electrical devices for the given reasons: High resistance, High permeability, Minimum hysteresis loss. 3-d) The rating of mostly electrical equipment shows its capability to sustain the mechanical load without overheating. There are two types of losses in the transformer due to the heating effect known as iron loss, and another is known as copper loss. The iron loss depends upon voltage, whereas copper loss depends upon current so that transformer is rated in KVA (KVA (kilo-Volt-Ampere) 4-d) Transformers have broad applications for various industries; mainly, distribution transformers are filled with oil. The two-primary function of the transformer oil is given below Insulator: The transformer oil has high dielectric strength; it means it can withstand very high voltage; this is the only reason it acts as an insulator in the transformer. Coolant: As we know, the transformer's coils are made up of copper and carrying a very high current, so it becomes hot in a very short time. The transformer oil is a good conductor of electricity and heat, so it reduces the coil's temperature. 5-d) Stones or crushed rock are provided in the substation to provide an extra layer of high resistance between the soil and a person walking or standing over there. It provides a safety layer that reduces the step and touch voltages that occur during ground faults, which can happen both inside and outside the substation. All substations are designed with a ground grid. Copper conductors are arranged in a grid pattern and laid in trenches dug into and buried in the soil when the substation is constructed. If the crushed rock were not used, more copper would be needed in the ground grid to achieve tolerable step and touch voltages during ground faults. 6-(a) In a step-down transformer current increases and voltage decreases.

CASE STUDY-5	RESONANT CIRCUITS conditions - i.e. the resonant frequency - the current reaches its highest possible value (assuming a constant source voltage), a condition termed series resonance. Thus, a series circuit is said to be resonant when the inductive reactance equals the capacitive reactance. When the circuits are in resonance, the impedance of the circuit is at a minimum and is equal to the circuit resistance. The current flowing in the circuit is at its highest possible point and is in phase with the applied voltage. In addition, the circuit acts as a purely resistive circuit. The voltage across the inductance is equal to the voltage across the capacitance, and is relatively high. In fact it may exceed the supply voltage. Although numerically equal, these emf's have opposite polarity and the resultant voltage is zero.

	Vector diagram (left) & vectorial addition of voltage (right) for the circuit of fig. 
1	The phase difference between the alternating current and emf is π/2. Which of the following cannot be the constituent of the circuit? (a) C alone (b) L alone (c) L and C (d) R and L
2	In an LCR-series ac circuit, the voltage across each of the component L, C and R is 50 V. The voltage across the LC-combination will be (a) 50 V (b) 50√2 V (c) 100 V (d) zero
3	Reciprocal of impedance is (a) susceptance (b) conductance (c) admittance (d) trans conductance
4	In the case of an inductor (a) voltage lags the current by π/2 (b) voltage leads the current by π/2 (c) voltage leads the current by π/3 (d) voltage leads the current by π/4
5	In series LCR circuit, the phase angle between supply voltage and current is (a) $\tan\phi = \frac{X_L - X_C}{R}$ (b) $\tan\phi = \frac{R}{X_L - X_C}$ (c) $\tan\phi = \frac{R}{X_L + X_C}$ (d) $\tan\phi = \frac{X_L + X_C}{R}$
KEY	1-(c), 2-(d), 3-c, 4-b, 5-a
Explanation	1-(c) When both L and C components are there then phase difference could be zero, less than or greater than π/2. 2-(d) The voltage across L and C are out of phase. Hence the voltage across the LC combination is zero. 3-(c) admittance 4-(b) voltage leads the current by π/2
CASE STUDY -6	Calculation of Resonant Frequency Although coil-capacitor combinations may be designed to resonate at any frequency, resonant circuits find their widest application in the radio frequency range. The series resonant circuit is in a state of resonance when the inductive reactance and the capacitive reactance are exactly equal. The inductive reactance will be exactly the same as the (B) Graph showing relationship between current and frequency and the circuit will be in a state of resonance. At this point, the voltage drops across the inductive and capacitive reactance's are equal, and since they are opposite in phase, they cancel each other. As a result, the only effective opposition to current flow in the circuit is the resistance. $X_L = X_C, \omega L = \frac{1}{\omega C}, \omega^2 = \frac{1}{LC}, (2\pi f)^2 = \frac{1}{LC}, f = \frac{1}{2\pi\sqrt{LC}}$

	
1	Capacitance is charged from C to 2C. For resonant frequency to remain unchanged, the inductance should be changed from L to (a) 4 L (b) 2 L (c) L/2 (d) L/4
2	In a series, LCR-circuit, resonant frequency depends on (a) $\frac{L}{C}$ (b) $\sqrt{LC}$ (c) $\frac{1}{\sqrt{LC}}$ (d) $\sqrt{\frac{L}{C}}$
3	Choose the correct statement. (a) A capacitor can conduct a dc circuit but not an inductor. (b) In a dc circuit the inductor can conduct but not a capacitor. (c) In dc circuit both the inductor and capacitor cannot conduct. (d) The inductor has infinite resistance in a dc circuit.
4	A coil of self-inductance L is connected in series with a bulb B and an ac source. Brightness of the bulb decreases when (a) Frequency of the ac source is decreased. (b) Number of turns in the coil is reduced. (c) A capacitance of reactance $X_C = X_L$ in included. (d) An iron rod is inserted in the coil.
5	In an alternating current circuit consisting of elements in series, the current increases on increasing the frequency of supply. Which of the following elements are likely to constitute the circuit? (a) Only resistor (b) Resistor and inductor (c) Resistor and capacitor (d) Only inductor
KEY	**1-c, 2-c, 3-b, 4-d, 5-c**
Explanation	1-(c) Since, Resonance frequency, $f_r = 1/2\pi\sqrt{LC}$ when C is changed 2C, L should be change to L/2. 2-(c) Resonance frequency, $\nu_r = 1/\sqrt{LC}$ 3-(b) In dc circuit, an inductor offers zero resistance to dc, while a capacitor offers infinite resistance. 4-(d) Brightness of the bulb decreases when inductive reactance increases, i.e. when iron rod is inserted in the coil, its inductance L increases, hence current decreases. 5- (c) Resistor and capacitor

<table>
<tr><td>CASE STUDY-7</td><td>Bottle Dynamo: A bottle dynamo is a small generator to generate electricity to power the bicycle light. Dynamo generates DC but a bottle dynamo generates AC. Newer models are now available with a rectifier. The available DC can power the light and small electronic gadgets. This is also known as sidewall generator since it operates using a roller placed on



the sidewall of bicycle tyre. When the bicycle is in motion, the dynamo roller is engaged and electricity is generated as the tyre spins the roller. When engaged, a dynamo requires the bicycle rider to exert more effort to maintain a given speed than would otherwise be necessary when the dynamo is not present or disengaged. Bottle dynamos can be completely disengaged during day time when cycle light is not in use. In wet conditions, the roller on a bottle dynamo can slip against the surface of the tyre, which interrupts the electricity generated. This cause the lights to go out intermittently</td></tr>
<tr><td>1</td><td>Why bottle dynamo is not a dynamo?
(A) It generates AC only (B) It generates DC only
(C) It looks like a bottle (D) It requires no fuel to operate</td></tr>
<tr><td>2</td><td>Can you recharge the battery of your mobile phone with the help of bottle dynamo?
(A) Yes (B) No
(C) Yes, when a rectifier is used (D) Yes, when a transformer is used</td></tr>
<tr><td>3</td><td>How Bottle generator generates electricity?
(A) When fuel is poured in the bottle. (B) When cycle is in motion.
(C) When it is mounted properly. (D) When wind blows.</td></tr>
<tr><td>4</td><td>Bulb of bicycle light glows:
(A) with AC supply only. (B) with DC supply only
(C) with both AC and DC supply. (D) only when AC supply is rectified.</td></tr>
<tr><td>5</td><td>Which one of the following is not an advantages of newer model of bottle dynamo?
(A) Works intermittently when it roller slips on tyre
(B) Small electronic gadgets can be charged
(C) Can be easily disengaged during day time
(D) Requires no fuel</td></tr>
<tr><td>KEY</td><td>1- A, 2-C, 3-B, 4-C, 5-A</td></tr>
<tr><td>Explanation</td><td>1-A) Dynamo generates DC. But bottle dynamo generates AC. So, it is not a dynamo in that sense. But, it generates electricity for bicycle light.
2-C): Newer models of bottle generators are now available with a rectifier. DC available from such bottle generator can be used directly for charging mobile phone. Otherwise with the old models, a rectifier is to be attached to convert AC to DC.
3-B) Bottle generator is also known as sidewall generator since it operates using a roller placed on the sidewall of bicycle tyre. When the bicycle is in motion, the dynamo roller is engaged and electricity is generated as the tyre spins the roller.</td></tr>
</table>

	4-C): Normal lamps work with both AC and DC. So, bottle generators of older model or newer model can be directly used for bicycle lamp. 5-A) In wet conditions, the roller on a bottle dynamo (old model or new model) can slip against the surface of the tyre, which interrupts the electricity generated. This causes the lights to go out intermittently. This is not an advantage.
CASE STUDY-8	Tuning a radio set: In essence the simplest tuned radio frequency receiver is a simple crystal set. Desired frequency is tuned by a tuned coil / capacitor combination, and then the signal is presented to a simple crystal or diode detector where the amplitude modulated signal, is demodulated.   This is then passed straight to the headphones or speaker. In radio set there is an LC oscillator comprising of a variable capacitor (or sometimes a variable coupling coil), with a knob on the front panel to tune the receiver. Capacitor used in old radio sets is gang capacitor. It consists of two sets of parallel circular plates one of which can rotate manually by means of a knob. The rotation causes overlapping areas of plates to change, thus changing its capacitance. Air gap between plates acts as dielectric. The capacitor has to be tuned in random corresponding to the frequency of a station so that the LC combination of the radio set resonates at the frequency of the desired station. When capacitive reactance (XC) is equal to the inductive reactance (XL), then the resonance occurs and the resonant frequency is given by $X_L = X_C, \omega L = \frac{1}{\omega C}, \omega^2 = \frac{1}{LC}, (2\pi f)^2 = \frac{1}{LC}, f = \frac{1}{2\pi\sqrt{LC}}$ Current amplitude becomes maximum at the resonant frequency. It is important to note that resonance phenomenon is exhibited by a circuit only if both L and C are present in the circuit. Only then do the voltages across L and C cancel each other (both being out of phase) and the Current amplitude is maximum, the total source voltage appearing across R. This means that we cannot have resonance in a RL or RC circuit.
1	Name the phenomenon involved in tuning a radio set to a particular radio station. (A) Stabilization (B) Rectification (C) Resonance (D) Reflection
2	Resonance may occur in: (A) RL circuit (B) RC circuit (C) LC circuit (D) Circuit having resistor only
3	Resonance frequency is equal to: (A) 1 LC (B) $\frac{1}{\sqrt{LC}}$ (C) L C (D) C L
4	Resonance occurs only when: (A) $X_C = R$ (B) $X_L = R$ (C) $X_L = X_C$ (D) $X_C > X_L$
5	Capacitor used in radio set for tuning is a: (A) Parallel plate capacitor (B) Spherical capacitor (C) Paper capacitor (D) Electrolytic capacitor
KEY	1-C, 2-C, 3-B, 4-C, 5-A
Explanation	1-C) Phenomenon involved in tuning a radio set to a particular radio station is resonance. The capacitor has to be tuned in tandem corresponding to the

	frequency of a station. So, that the LC combination of the radio set resonates at the frequency of the desired station. 2-C) Simple radio receiver is a simple crystal set with a coil and capacitor combination. Desired frequency is tuned by tuning the coil - capacitor combination. Tuning means to make capacitive reactance (X_C) equal to the inductive reactance (X_L), so that the resonance occurs. 3-B) The resonant frequency is given by $f_r = \frac{1}{2\pi\sqrt{LC}}$ 4-C) At resonance, capacitive reactance (X_C) is equal to the inductive reactance (X_L). Circuit is totally resistive and the current amplitude becomes maximum. 5-A) Capacitor used in old radio is a parallel plate capacitor. It consists of two sets of parallel circular plates, one of which can rotate manually by means of a knob. The rotation causes overlapping areas of plates to change, thus changing its capacitance.

UNIT-V: ELECTROMAGNETIC WAVES

MCQs

1. Which of the following rays is emitted by human body?
   a) X-rays b) UV rays c) Visible rays d) IR rays
2. All components of the electromagnetic spectrum in vacuum have the same
   a) Energy b) Velocity c) Wavelength d) Frequency
3. If v_g, v_X and v_m are the speeds of gamma rays, X-rays and microwaves respectively in vacuum, then
   a) $v_g > v_X > v_m$ c) $v_g < v_X < v_m$
   b) $v_X > v_g > v_m$ d) $v_g = v_X = v_m$
4. Which of the following will deflect in electric field?
   a) Visible light b) gamma rays c) cathode rays d) ultraviolet rays
5. An electromagnetic radiation has energy of 13.2 KeV. Then the radiation belongs to the region of
   a) Visible light b) Ultraviolet c) Inferared d) X-ray
6. A charged particle oscillates about its mean equilibrium position with a frequency of $10^9 Hz$. Frequency of the electromagnetic waves produced by the oscillator is
   a) 10Hz b) 10^5 Hz c) 10^9Hz d) 10^{10}Hz
7. If a source is transmitting electromagnetic wave of frequency $8.2 \times 10^6 Hz$, then wavelength of the electromagnetic waves transmitted from the source will be
   a) 36.6m b) 40.5m c) 42.3m d) 50.9m
8. Which of the following is absorbed by the ozone layer?
   a) Only gamma rays b) Visible light c) Radio wave d) UV rays
9. The unit of expression $\mu_o \varepsilon_o$ is
   a) m/s b) $m^2 s^{-2}$ c) $s^2 m^{-2}$ d) s/m
10. A radiowave has a maximum magnetic field induction of 10^{-4}T on arrival at a receiving antenna. The maximum electric field intensity of such a wave is
    a) Zero b) $3 \times 10^4 Vm^{-1}$ c) $5.8 \times 10^{-4} V/m$ d) $3.0 \times 10^{-5} V/m$
11. Given the wave function (in SI units) for a wave to be $\varphi(x,t) = 10^3 \sin \pi(3 \times 10^6 x - 9 \times 10^{14} t)$. The speed of the wave is
    a) $9 \times 10^{14} m/s$ b) $3 \times 10^8 m/s$ c) $3 \times 10^6 m/s$ d) $3 \times 10^7 m/s$

12. A laser beam is sent to the moon and reflected back to earth by any mirror placed on the moon by an astronaut. If the moon is 384000km from earth, how long does it take the light to make the round trip?
    a) 5 min   b) 2.5 min   c) 2.56s   d) 500s
13. The magnetic field of an Electromagnetic wave is given by $B_y = 3 \times 10^{-7} \sin(10^3 x + 6.29 \times 10^{12} t)$. The wavelength of the electromagnetic wave is
    a) 6.28cm   b) 3.14cm   c) 0.63cm   d) 0.32cm
14. Which of the following electromagnetic wave have the longest wavelength?
    a) Heat wave   b) Light waves   c) Radio waves   d) UV waves
15. The energy of X-ray photon is 2200eV. Its frequency would be
    a) $5.3 \times 10^{16} Hz$ b) $5.3 \times 10^{17} Hz$ c) $5 \times 10^{17} Hz$ d) $5 \times 10^{16} Hz$

ASSERTION – REASONING TYPE QUESTIONS

Two statements are given –one labelled Assertion (A) and other labelled Reason (R). Select the correct answer to these questions from the options as given below.

a) If both Assertion and Reason are true and Reason is correct explanation of Assertion.
b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
c) If Assertion is true but Reason is false.
d) If both Assertion and Reason are false

16. **Assertion**: Velocity of light is constant in all media
    Reason: Light is an electromagnetic wave which has constant velocity in all media
17. **Assertion** : In an electromagnetic wave, magnitude of magnetic field vector is much smaller than the magnitude of electric field vector.
    Reason: Energy of electromagnetic waves is not shared equally by the electric and magnetic fields.
18. **Assertion**: When a charged particle moves in a circular path, it produces electromagnetic wave.
    Reason: Accelerated charged particle produce electromagnetic waves.
19. **Assertion**: In electromagnetic waves electric field and magnetic field are perpendicular to each other.
    Reason: Electric field and magnetic field of electromagnetic wave are self sustaining.

CASE BASED QUESTIONS

20. In an electromagnetic wave both the electric and magnetic fields are perpendicular to the direction of propagation that is why electromagnetic waves are transverse in nature. Electromagnetic waves carry energy as they travel through space and this energy is shared equally by the electric and magnetic fields. Energy density of electromagnetic waves is the energy in unit volume of the space through which the wave travels.
    (i) The electromagnetic waves propagated perpendicular to both $\vec{E}$ and $\vec{B}$. The electromagnetic waves travel in the direction of
    a) $\vec{E} \cdot \vec{B}$ b) $\vec{E} \times \vec{B}$ c) $\vec{B} \cdot \vec{E}$ d) $\vec{B} \times \vec{E}$

(ii) Fundamental particle in an electromagnetic wave is

a) Photon b) electron c) proton d) neutron

(iii) Electromagnetic waves are transverse in nature is evident by

a) Polarization b) Interference c) Reflection d) Diffraction

(iv) For a wave propagating in a medium, identify the property that is independent of the others.

a) Velocity b) Wavelength

c) Frequency d) All of these depend on each other

(v) The electric and magnetic fields of an electromagnetic waves are

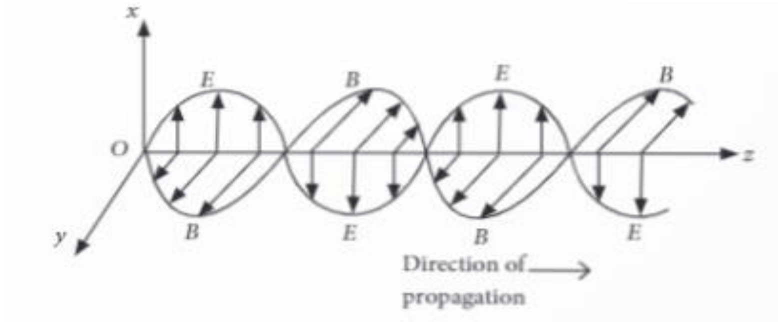
a) In opposite phase and perpendicular to each other

b) In opposite phase and parallele to each other

c) In phase and perpendicular to each other

d) In phase and parallel to each other

21. A stationary charge produces only an electrostatic field while a charge in uniform motion produces a magnetic field, that does not change with time. An oscillating charge is an example of accelerating charge. It produces an oscillating magnetic field, which in turn produces an oscillating electric fields and soo on. The oscillating electric and magnetic fields, which in turn produces an oscillating electric fields and so on. The oscillating electric and magnetic fields regenerate each other as a wave which propogates through space.



(i) Magnetic field in a plane electromagnetic wave is given by $\vec{B} = B_o \sin(kx + \omega t)\,\hat{j}T$. Expression for corresponding electric field will be (Where c is speed of light)

(a) $\vec{E} = -B_o c \sin(ky + \omega t)\,\hat{k}\;V/m$ c) $\vec{E} = \frac{B_o}{c}\sin(kx + \omega t)\,\hat{k}\;V/m$

(b) $\vec{E} = B_o c \sin(kx - \omega t)\,\hat{k}\;V/m$ d) $\vec{E} = B_o c \sin(kx + \omega t)\,\hat{k}\;V/m$

(ii) The electric field component of a monochromatic radiation is given by $\vec{E} = 2E_o\hat{j}\cos kz\;\cos\omega t$. Its magnetic field *is given by*

a) $\frac{2E_o}{c}\hat{j}\;\cos kz\;\cos wt$ c) $\frac{2E_o}{c}\hat{j}\;\sin kz\;\sin wt$

b) $\frac{2E_o}{c}\hat{j}\;\sin kz\;\cos wt$ d) $-\frac{2E_o}{c}\hat{j}\;\sin kz\;\sin wt$

(iii) A plane em wave of frequency 25 MHz travels in a free space along x-direction. At a particular point in space and time , E=6.3 $\hat{j}$ V/m. What is magnetic field at that time?

a) 0.095µT b) 0.124µT c) 0.089µT d) 0.022µT

(iv) A plane electromagnetic wave travels in free space along x-axis. At a particular point in space, the electric field along y-axis is 9.3 V/m. The magnetic induction (B) along z-axis is

a) $3.1 \times 10^{-8}T$ b) $3 \times 10^{-5}T$ c) $3 \times 10^{-6}T$ d) $9.3 \times 10^{-6}T$

22. All the known radiation from a big family of electromagnetic waves which streched over a large range of wavelengths. Electromagnetic wave include radio wave, microwaves, visible light waves, infera red rays, UV rays, X-rays and gamma rays. The ordinary distribution of the electromagnetic waves in accordance with their wavelength or frequency into distinct groups having widely differing properties is electromagnetic spectrum

(i) Which wavelength of the sun is used finally as heat energy?
a) Radio wave b) Infrared wave c) Visible light d) microwave

(ii) Which of the following electromagnetic radiation have the longest wavelength?
a) X-rays b) gamma rays c) microwaves d) radiowaves

(iii) Which one of the following is not electromagnetic in nature?
a) X-ray b) gamma ray c) sound wave d) visible light

(iv) Which of the following has minimum wavelength?
a) X-rays b) ultra violet rays c) gamma rays d) visible light

(v) The decreasing order of wavelength of inferared, microwave, ultraviolet and gamma rays is
a) Microwave, inferared, ultraviolet,gamma rays
b) Gamma rays, ultraviolet, inferared, microwave
c) Microwave , gamma rays, inferared, ultraviolet
d) Inferared, microwave, ultraviolet, gamma rays

Electromagnetic waves (KEY)

Q.No.	Answer	Q.No.	Answer
1	d) IR rays	2	b) Velocity
3	d) $v_g = v_X = v_m$	4	c) cathode rays
5	d) X-ray	6	c) 10^9Hz
7	a) 36.6m	8	d) Ultraviolet rays
9	c) s^2m^{-2}	10	b) $3 \times 10^4 Vm^{-1}$
11	b) $3 \times 10^8 m/s$	12	c) 2.56s
13	c) 0.63cm	14	c) Radio waves
15	b) $5.3 \times 10^{17} Hz$	16	(d) as velocity of light depends on medium
17	(d)	18	(a)
19	(b)		
20	(i) - b) $\vec{E} \times \vec{B}$ (ii) - a (iii) - a (iv) - c) Frequency (As frequency does not change when a wave propagates through a medium, it is independent of other factors. Hence, this is the correct option) (v) - c) In phase and perpendicular to each other		
21	(i) d) $\vec{E} = B_o c \sin(kx + \omega t)\,\hat{k}\ V/m$ (ii)-a (iii)-d (iv)-a		
22	(i) b) Infrared wave (ii)-d (iii)-c (iv)-c (v)-a		

UNIT-VI : OPTICS

Ch-9 : Ray Optics and Optical Instruments
&
Ch-10 : Wave Optics

MCQ's

1.A glass lens is immersed in water. What will be the effect on the power of lens?
(A) increase (B) decrease (C) constant (D) not depends

2.The maximum magnification that can be obtained with convex lens of focal length 2.5cm is (the least distance of distinct vision is 25 cm)

(A) 10 (B) 0.1 (C) 62.5 (D) 11

3.The objective lens of an astronomical telescope has a large aperture to
(A) increase span of observation (B) have low dispersion
(C) reduce spherical aberration (D) have high resolution

4.Two lenses of focal lengths 20 cm and - 40cm are held in contact. If an object lies at infinity, image formed by the lens combination will be at
(A) infinity (B) 20cm (C) 40cm (D) 60cm

5.The characteristic feature of light which remains unaffected on refraction is
(A) speed (B) frequency (C) wavelength (D) velocity of light

6.The air bubble inside water shine due to
(A) Reflection (B) Refraction (C) Total internal reflection (D) None of these

7.How does the focal length of a convex lens changes if mono-chromatic red light is used instead of violet light?
(A) Focal length is increased when red light is used
(B) Focal length is decreased when red light is used
(C) Focal length is remains same when red light is used
(D) Not depends on colour of light

8.When a convex lens placed inside a transparent medium of refracting index greater than that of its own material
(A) It behaves as concave lens (B) It behaves as convex lens
(C) It behaves as a glass slab (D) It behaves as a glass prism

9.The deviation of a ray on passing through a prism is d =(μ-1) A,for
(A) All conditions (B) small angle A
(C) Large angle A (D) In minimum angle of deviation case.

10.A thin prism of 12° angle gives a deviation of 6°. The refracting index of a material of the prism
(A) 3/2 (B) 4/3 (C) 8/9 (D) 9/8

11.The radius of curvature of the convex surface of a Plano- convex lens whose focal length is 0.3m & the refractive index of material is 1.5 is
(A) 1.5m (B) 0.15m (C) 0.5m (D) 1 .25m

12.The magnifying power of an astronomical telescope in the normal adjustment position is 100. The distance between objective & the eyepiece is 101cm.what is the focal length of objective.
(A) 100cm (B) 1cm (C) 50 cm (D) 11cm

13.A Tank is filled with water to a height of 12.5cm. The apparent depth of a needle lying at bottom of tank is measured by a microscope to be 9.4cm.What is the refractive of water?
(A) 1.33 (B) 1.5 (C) 1.13 (D) 1.45

14.Two thin lenses of focal lengths 20 cm and 25 cm are placed in contact. The effective power of the combination is:
(A) 45 D (B) 9 D (C) 19 D (D) 6 D

15.The angle of deviation for a prism is greatest for:
(A) violet (B) red. (C) orange (D) yellow

16.An astronomical refractive telescope has an objective of focal length 20 m and an eyepiece of focal length 2 cm. Then
(A) the magnification is 1000 (B) the length of the telescope tube is 20.02 m
(C) the image formed of inverted (D) all of these

17.An astronomical refractive telescope has an objective of focal length 20 m and an eyepiece of focal length 2 cm. Which one of the following is not possible?
(A) The length of the telescope tube is 20.02 m.
(B) The magnification is 1000.
(C) The image formed is inverted.
(D) An objective of a larger aperture will increase the brightness and reduce chromatic aberration of the image.

18.A concave mirror is held in water. What should be the change in the focal length of the mirror?
(A) Halved (B) Doubled (C) Remains the same (D) Increases exponentially

19.A convex lens is dipped in a liquid whose refractive index is equal to the refractive index of the lens. Then its focal length will
(A) become zero (B) become infinite
(C) become small, but non-zero (D) remain unchanged

20.Which of-the following is not a property of light?
(A) It can travel through vacuum (B) It has a finite speed
(C) It requires a material medium for its propagation (D) It involves transportation energy

21. Two concave mirrors have the same focal length but the aperture of one is larger than that of the other. Which mirror forms the sharper image?
(A) Plane (B) Concave (C) Convex (D) Prism

22. 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, the displacement of the image will be:
(A) 30 cm away from the mirror (B) 36 cm away from the mirror
(C) 30 cm towards the mirror (D) 36 cm towards the mirror

23. A man stands in front of a mirror of special shape. He finds that his image has a very small head, a fat body, and legs of normal size. What can we say about the shapes of the three parts of the mirror?

(A) Convex, Concave, Plane (B) The plane, Concave, Convex
(C) Concave, Convex, Plane (D) Convex, Plane, Concave

24.The refractive indices (R.I.) of glass and water with respect to air are 3/2 and 4/3 respectively. The R.I. of glass with respect. to water is:
(A) 8/9 (B) 9/8 (C) 7/6 (D) 2

25.Which of the following colour of white light deviated most when passes through a prism?
(A) Red light (B) Violet light (C) Yellow light (D) Both (i) and (ii)

26.Two lenses of focal lengths 20 cm and – 40 cm are held in contact. The image of an object at infinity will be formed by the combination at
(A) 10 cm (B) 20 cm (C) 40 cm (D) infinity

27.A convergent lens will become less convergent in

(A) Oil (B) water (C) both of (i) and (ii) (D) none of these

28. Two beams of red and violet colour are made to pass separately through a prism (angle of the prism is 60°). In the position of minimum deviation, the angle of refraction will be
(A) 30° for both the colours (B) greater for the violet colour
(C) greater for the red colour (D) equal but not 30° for both the colours

29. When light is refracted into a medium,
(A) its wavelength and frequency both increase
(B) its wavelength increases but frequency remains unchanged
(C) its wavelength decreases but frequency remains unchanged
(D) its wavelength and frequency both decrease

30. A ray of light incident at an angle θ on a refracting face of a prism emerges from the other face normally. If the angle of the prism is 5° and the prism is made of a material of refractive index 1.5, the angle of incidence is

(A) 7.5° (B) 5° (C) 15° (D) 2.5°

31. A real, inverted and equal in size image is formed by
(A) a concave mirror (B) a convex mirror (C) a plane mirror (D) none of these

32. If a spherical mirror is immersed in a liquid. its focal length will
A) increase (B) decrease (C) remain unchanged (D) depend on the nature of liquid

33. When a beam of light is incident on a plane mirror, it is found that a real image is formed. The incident beam must be
(A) Converging (B) Diverging
(C) Parallel (D) Formation of real image by a plane mirror is impossible

34. An object is placed symmetrically between two plane mirrors, inclined at an angle of 72°, then the total number of images observed is
(A) 5 (B) 4 (C) 2 (D) Infinite

35. A person 1.6 m tall is standing at the centre between two walls three metre high. What is the minimum size of a plane mirror fixed on the wall in front of him, if he is to see the full height of the wall behind him?
(A) 0.8 m (B) 1 m (C) 1.5 m (D) 2.3 m

36. While capturing solar energy for commercial purposes we use
(A) Parabolic mirrors (B) Plane mirrors (C) Convex mirrors (D) Concave mirrors

37. A convex mirror is used to form an image of a real object. Then mark the wrong statement
(A) The image lies between the pole and focus (B) The image is diminished in size
(C) The image is erect (D) The image is real

38. A convex mirror has a focal length f. A real object is placed at a distance f in front of it, from the pole. It produces an image at
(A) Infinity (B) f (C) f/2 (D) 2f

39. An object placed in front of a concave mirror of focal length 0.15 m produces a virtual image, which is twice the size of the object. The position of the object with respect to the mirror is

(A) –5.5 cm (B) –6.5 cm (C) –7.5 cm (D) –8.5 cm

40.When a light ray from a rarer medium is refracted into a denser medium, its
(A) Speed increases, wavelength increases (B) Speed decreases, wavelength increases
(C) Speed increases, wavelength decreases (D) Speed decreases, wavelength decreases

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41.What happens if one of the slits, say S_1 in Young's double, slit experiment-is covered with a glass plate which absorbs half the intensity of light from it?
(A) The bright fringes become less-bright and the dark fringes have a finite light intensity
(B) The bright fringes become brighter and the dark fringes become darker
(C) The fringe width decreases
(D) No fringes will be observed

42.What happens to the interference pattern the two slits S_1 and S_2 in Young's double experiment are illuminated by two independent but identical sources?
(A) The intensity of the bright fringes doubled
(B) The intensity of the bright fringes becomes four times
(C) Two sets of interference fringes overlap
(D) No interference pattern is observed

43. Two sources of light are said to be coherent when both give out light waves of the same:
(A) amplitude and phase (B) intensity and wavelength
(C) speed (D) wavelength and a constant phase difference

44. Which of the following is conserved when light waves interference?
(A) phase (B) intensity (C) amplitude (D) none of these

45.The locus of all particles in a medium, vibrating in the same phase is called
(A) wavelet (B) fringe (C) wave front (D) None of these

46.Wavefront is the locus of all points, where the particles of the medium vibrate with the same
(A) phase (B) amplitude (C) frequency (D) period

47. When light suffers reflection at the interface between water and glass, the change of phase in the reflected wave is
(A) zero (B) π (C) $\pi/2$ (D) 2π

48. Two sources of light are said to be coherent, when they give light waves of same
(A) amplitude and phase (B) wavelength and constant phase difference
(C) intensity and wavelength (D) phase and speed

49. To observe diffraction, the size of the obstacle
(A) should be X/2, where X is the wavelength. (B) should be of the order of wavelength.
(C) has no relation to wavelength. (D) should be much larger than the wavelength.

50. The colours on the soap bubble is due to
(A) Interference (B) Diffraction (C) Polarisation (D) Reflection

51. Which of the following phenomenon is not explained by Huygens's wave theory?
(A) Diffraction (B) Polarisation (C) Photoelectric effect (D) Interference

52. In Young's double slit experiment, the fringe width is β . If the entire arrangement is now placed

inside a liquid of refractive index μ , the fringe width will become
(A) μ β (B) β/μ (C) β/(μ+1) (D) β/(μ−1)

53.In the phenomena of Diffraction of light when the violet light is used in the experiment is used instead of red light then.
(A) Fringe width increases (B) No change in fridge width
(C) Fringe width decreases (D) Colour pattern is formed

54. In the Young's double slit experiment both the slits are similar. If the length of one of the slits is halved, which of the following is true?
(A) Bright fringes become narrower. (B) Bright fringes become wider.
(C) Dark fringes become darker (D) Dark fringes become brighter.

55. Ratio of intensities of two waves are given by 4 :1. Then the ratio of the amplitudes of the two waves is
(A) 2: 1 (B) 1: 2 (C) 4: 1 (D) 1: 4

56. The light sources used in Young's double slit experiment are:
(A) Incoherent (B) Coherent (C) White light (D) Blue-green-red Light.

57. If the width of the slit in single slit diffraction experiment is doubled, then the central maximum of diffraction pattern becomes:
(A) broader and brighter (B) broader and fainter
(C) sharper and fainter (D) sharper and brighter

58. Angular width of interference fringe depends on
(A) Distance between Slit and Screen (B) Ratio of the wavelength and Slit width
(C) Wavelength of light (D) Width of Slit

59. In a Young's double slit experiment, the separation between the slits is 0.1 mm, the wavelength of light used is 600nm and the interference pattern is observed on a screen 1m away. Find the separation between bright fringes.
(A) 6.0 mm (B) 6.6 mm (C) 6 m (D) 60 cm

60. The wave-front due to source situated at the infinity is
(A) Spherical (B) Cylindrical (C) Plane (D) Rectangular

ASSERTION & REASON TYPE QUESTIONS - OPTICS

Answer: (A) Both are correct and Reason is correct explanation of Assertion.
Answer: (B) Both are correct but Reason is not the correct explanation of Assertion.
Answer: (C) Assertion is correct but Reason is wrong.
Answer: (D) Both are wrong.

61. **A:** The speed of light in vacuum doesn't depend on nature of the source, direction of propagation, motion of the source or observer wavelength and intensity of the wave.
R: The speed of light in vacuum is a universal constant independent of all the factors listed and anything else.

62. **A:** When monochromatic light is incident on a surface separating two media, the reflected and refracted light both have the same frequency as the incident frequency.
R: At any interface between the two media, the electric (and magnetic) fields must satisfy certain boundary conditions for all times & frequency determines the time dependence of fields.

63.**A:** When light travels from a rarer to a denser medium, it loses some speed but it doesn't imply a reduction in the energy carried by the light wave.
R: Energy carried by a wave depends on the amplitude of the wave and not on the speed of wave propagation.

64. **A:** When a narrow pulse of light is sent through a medium, it doesn't retain its shape as it travels through the medium.
R: Since the speed of propagation in a medium depends on wavelength, Different wavelength components of the pulse travel with different speeds.

65. **A:** In the wave picture of light, intensity of light is determined by the square of the amplitude of the wave.
R: In the photon picture of light, for a given frequency, intensity of light is determined by the number of photons incident per unit area.

66. **A:** The phase difference between any two points on a wave front is zero.
R: Corresponding to a beam of parallel rays of light, the wave fronts are planes parallel to one another.

67. **A:** The law of conservation of energy is violated during interference.
R: For sustained interference the phase difference between the two waves must change with time.

68. **A:** When the apparatus of YDSE is brought in a liquid from air, the fringe width decreases.
R: The wavelength of light decreases in the liquid.

69. **A:** For observing traffic at our back, we prefer to use a convex mirror.
R:A convex mirror has a larger field of view than a plane mirror or concave mirror.

70.**A:**In passing through a lens or prism, the phase difference between two waves does not change.
R:The optical path lengths of all rays are same.

71. **A:**A convex lens may be diverging.
R:The nature of a lens depends upon the refractive indices of the material of lens and surrounding medium besides geometry.

72. **A:**The power of a thin lens does not depend upon the surrounding medium.
R:Power of a thin lens $= \frac{\mu}{f}$.

73. **A:**If white light is used in YDSE, colored fringes are obtained.
R:The fringe width is proportional to the wavelength (color) of light.

74.**A:** Superposition takes place only between those waves emitted by coherent sources.
R: All coherent sources emit energy in proper order.

75. **A:**When a glass prism is immersed in water, the deviation caused by prism decreases.
R:Refractive index of glass prism relative to water is less than relative to air.

76. **A:**An air bubble in water shines.
R:When light is incident from water to air, total internal reflection takes place at outer surface of bubble.

77. **A:**Thin films such as soap bubble or thin layer of oil spread on water show beautiful colours when illuminated by white light.
R:It is due to interference of Sun's light reflected from upper and lower surfaces of the film.

78. **A:** In YDSE central fringe is always a bright fringe.
R:If path difference at central fringe is zero then it will be a bright fringe.

79. **A:**When white light passes through a prism, deviation of violet light is more than green light.
R:In a prism average deviation is measured as deviation of yellow light.

80. **A:**A real object is kept on principle axis of mirror. Size of image measured is equal to size of object. The mirror must be plane mirror.
R:For a plane mirror magnification is unity.

ANSWERS - OPTICS

1.	B	21.	B	41.	A	61.	A
2.	D	22.	B	42.	D	62.	A
3.	D	23.	A	43.	D	63.	A
4.	C	24.	B	44.	D	64.	A
5.	B	25.	B	45.	C	65.	B
6.	C	26.	C	46.	A	66.	B
7.	A	27.	B	47.	B	67.	D
8.	A	28.	A	48.	A	68.	A
9.	B	29.	B	49.	B	69.	A
10.	A	30.	A	50.	A	70.	C
11.	B	31.	A	51.	C	71.	A
12.	A	32.	C	52.	B	72.	D
13.	A	33.	A	53.	C	73.	D
14.	B	34.	B	54.	D	74.	D
15.	A	35.	B	55.	A	75.	A
16.	D	36.	A	56.	B	76.	A
17.	D	37.	D	57.	D	77.	A
18.	C	38.	C	58.	C	78.	D
19.	B	39.	C	59.	A	79.	B
20.	C	40.	D	60.	C	80.	D

CASE STUDY TYPE QUESTIONS - OPTICS

1) A compound microscope:

It is an optical instrument used for observing highly magnified images of tiny objects. Magnifying power of a compound microscope is defined as the ratio of the angle subtended at the eye by the final image to the angle subtended at the eye by the object, when both the final image and the objects are situated at the least distance of distinct vision from the eye. It can be given that: $m = m_e \times m_o$, where m_e is the magnification produced by the eye lens and m_o is the magnification produced by the objective lens. Consider a compound microscope that consists of an objective lens of focal length 2.0 cm and an eyepiece of focal length 6.25 cm separated by a distance of 15 cm.

(i) The object distance for eye-piece, so that final image is formed at the least distance of distinct vision, will be

(A) 3.45 cm (B) 5 cm (C) 1.29 cm (D) 2.59 cm

(ii) How far from the objective should an object be placed in order to obtain the condition described? in part (i)?

(A) 4.5 cm (B) 2.5 cm (C) 1.5 cm (D) 3.0 cm

(iii) What is the magnifying power of the microscope in case of least distinct vision?

(A) 40 (B) 30 (C) 20 (D) 50

(iv) The intermediate image formed by the objective of a compound microscope is

(A) real, inverted and magnified (B) real, erect and magnified
(C) virtual, erect and magnified (D) virtual, inverted and magnified

ANSWER KEY							
i.	(B)	ii.	(B)	iii.	(C)	iv.	(A)

2) . Power of a lens:

Power (P) of a lens is given as the reciprocal of focal length (P=1/f), where 'f' should be in meter and P is in Dioptre. For convex lens, power is positive and concave lens, power is negative. When two or more lenses are kept in contact then power of the combined lens is given as $P = P_1 + P_2 + P_3$ …….

(i) A convex lens is cut in to two equal parts, perpendicular to its axial line. The power of each part

(A) becomes zero (B) remain the same (C) decreases (D) increases

(ii)The two lenses of power +1.5D and +1.0D are placed in contact then the effective power of the combination will be

(A) 2.5D (B) 1.5 D (C) 0.5D (D) 3.25D

(iii) If the power of the combination of two lenses is 2.5D. The power of one lens is -1.5D.What is the focal length of the other lens?

(A)10cm (B) 20cm (C)25cm (D) 5cm

(iv)Two thin lens of focal length +10cm & -5cm are kept in contact, the power of the combination is

(A) -10D (B) -20D (C) 10D (D) 15D

ANSWER KEY							
i.	(C)	ii.	(A)	iii.	(C)	iv.	(B)

3. Refraction through a prism:

A prism is a portion of a transparent medium bounded by two planes face inclined to each other at a suitable angle. A ray of light suffers two refractions on passing through a prism and hence deviates through a certain angle from its original path. The angle of deviation of a prism is $\delta = (\mu-1) A$, through which a ray deviates on passing through a thin prism of small refracting angle A . If μ is the refractive index of the material of the prism then the prism formula is $\mu = \sin(A+\delta_m/2) / \sin(A/2)$.

(i) For which colour, angle of deviation is minimum?

(A) Red (B) Yellow (C) Violet (D) Blue.

(ii) When white light moves through vacuum

(A) All colours have same speed (B) Different colours have different speed
(C) Violet has more speed then red (D) Red has more speed then violet.

(iii)The deviation through a prism is maximum when angle of incidence is
(A) 45^o (B) 70^o (C)90^o (D)60^o

(iv) What is the deviation produced by a prism of angle 6^o? (μ=1.6)
(A) 3.6^o (B) 4.9^o (C) 7.9^o (D) 1.5^o

(v) A ray of light falling at an angle of 50^0 is refracted through a prism and suffers minimum deviation. If the angle of prism is 60^0, then the angle of minimum deviation is
(A) 45^0 (B) 75^0 (C) 50^0 (D) 40^0

ANSWER KEY									
i.	(A)	ii.	(A)	iii.	(C)	iv.	(A)	v.	(D)

4. **Total internal reflection**:

As we know that, when light ray travels from one medium to another, it changes its direction of path due to the change in optical density of the medium. When light ray travels from optically denser medium to the optically rarer medium then some of the light get reflected back in the same medium and remaining light get refracted in the second medium and such a phenomenon of light is called as internal reflection of light. Mirage is the best real-life example of total internal reflection of light. Right angled prisms, optical fibres etc., are mainly constructed on the basis of total internal reflection of light to reduce the decrease in amplitude of the sending signal.

(i) For critical angle the value of corresponding angle of refraction is____
(A)180° (B) less than 90° (C) greater than 90° (D) 90°

(ii) As the refractive index of the medium increases the corresponding value of critical angle for that medium ____
(A) decreases (B) increases
(C) remains same (D) independent of refractive index of the medium

(iii) In case of total internal reflection, for angle of incidence greater than critical angle the refraction of light is not possible because____
A) Snell's law of refraction gets satisfied
B) Snell's law of refraction cannot be satisfied
C) laws of refraction cannot be satisfied
D) can't say

(iv) What is mean by optically denser and optically rarer medium?

(v) How total internal reflection of light would be possible in case of optical fibres?

ANSWER KEY					
i.	(D)	ii.	(A)	iii.	(B)
(iv) Lower is the refractive index of the medium then lower its optical density also.					
(v) Optical fibres are made up of high-quality composite glass or quartz fibres which consist of core and cladding. The refractive index of core is higher than the cladding. So core acts as a rarer medium and cladding acts as the denser medium. The signal in the form of light is passed from one end of the fibre at a particular angel of incidence so that the light must get totally internally reflected. In such way, light get totally internally reflected many times along the length of the fibre					

and finally will be received at the other end without loss in intensity.

5. **Interference of light**:

The modification of intensity of light in a medium due to the superposition of two or more coherent rays is called interference of light. The point at which two waves are in phase or if trough of one wave coincides with the trough of other or crest of one wave coincides with the crest of other then the resultant intensity produced at that point will be larger and amplitude also maximum. Such points are the points where constructive interference takes place. While there are some points where two light waves are not in phase with each other and crest of one wave coincides with the trough of other and vice versa due to which resultant intensity at that point is minimum and amplitude also get decreased. Such points are the points where destructive interference takes place.

(i) For coherent sources of light, the phase difference must be___

(A) one (B) zero (C) either zero or constant (D) 90°

(ii) If the phase difference is 2π, the path difference of the two waves is

(A) λ (B)2λ (C) $\lambda/2$ (D) zero

(iii) For destructive interference

A) path difference is (n +1/2) times wavelength

B) phase difference is π, 3π, 5π

C) path difference is integral multiple of wavelengths

D) both A and B

(iv) The interference and diffraction of light explains which nature of light

(v) How conservation of energy is possible in interference and diffraction of light?

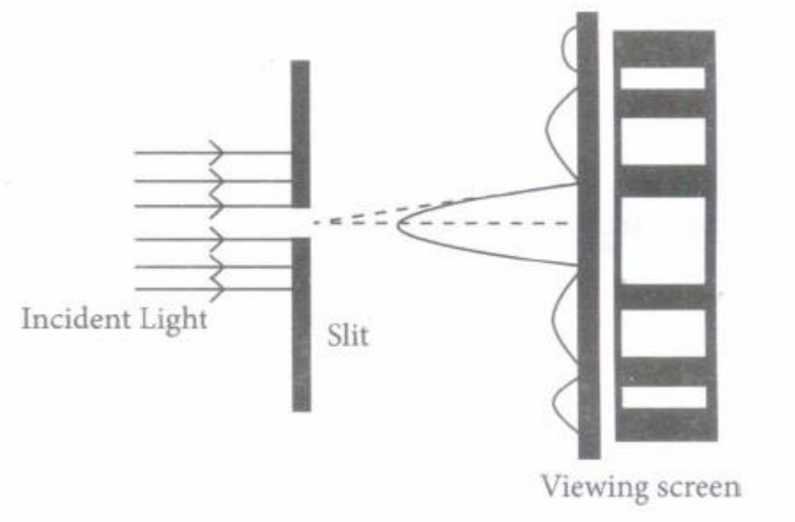
ANSWER KEY		
i. (C)	ii. (A)	iii. (D)
(iv) The phenomenon of interference of light and diffraction of light explains the wave nature light.		
(v) In interference and diffraction of light, there is a redistribution of light energy takes place. That means if a dark fringe with less light energy is produced then there will be also a bright fringe with high light energy will be produced in another region. Therefore, there will be no loss or gain in light energy takes place which obeys the law of conservation of energy.		

6. **Diffraction of light:**

When light from a monochromatic source is incident on a single narrow slit, it gets diffracted and a pattern of alternate bright and dark fringes is obtained on screen, called "Diffraction Pattern" of single slit. In diffraction pattern of single slit, it is found that

(I) Central bright fringe is ·of maximum intensity and the intensity of any secondary bright fringe decreases with increase in its order.

(II) Central bright fringe is twice as wide as any other secondary bright or dark fringe.



(i) A single slit of width 0.1 mm is illuminated by a parallel beam of light of wavelength 6000 A and diffraction bands are observed on a screen 0.5 m from the slit. The distance of the third dark band from the central bright band is

(A) 3 mm (B) 1.5 mm (C) 9 mm (D) 4.5 mm

(ii) In Fraunhoffer diffraction pattern, slit width is 0.2 mm and screen is at 2 m away from the lens. If wavelength of light used is 5000 λ, then the distance between the first minimum on either side the central maximum is

(A) 10^{-1} m (B) 10^{-2} m (C) 2×10^{-2} m (D) 2×10^{-1} m

(iii) Light of wavelength 600 nm is incident normally on a slit of width 0.2 mm. The angular width of central maxima in the diffraction pattern is (measured from minimum to minimum)

(A) 6×10^{-3} rad (B) 4×10^{-3} rad (C) 2.4×10^{-3} rad (D) 4.5×10^{-3} rad

(iv) A diffraction pattern is obtained by using a beam of red light. What will happen, if the red light is replaced by the blue light?

(A) bands disappear
(B) bands become broader and farther apart
(C) no change will take place
(D) diffraction bands become narrower and crowded together.

(v) To observe diffraction, the size of the obstacle

(A) should be A/2, where A is the wavelength. (B) should be of the order of wavelength.
(C) has no relation to wavelength. (D) should be much larger than the wavelength.

ANSWER KEY									
i.	(C)	ii.	(B)	iii.	(A)	iv.	(D)	v.	(B)

UNIT-VII: DUAL NATURE OF RADIATION AND MATTER

Ch-11: Dual Nature of Radiation and Matter

MCQs

1.Consider a beam of electrons (each electron with energy E_0) incident on a metal surface kept in an evacuated chamber. Then

(a) no electrons will be emitted as only photons can emit electrons

(b) electrons can be emitted but all with an energy E_0

(c) electrons can be emitted with any energy, with a maximum of E_0-φ (φ is the work function)

(d) electrons can be emitted with any energy, with a maximum of E_0

2.Threshold wavelength for a metal having work function W_o is λ. What is the threshold wavelength for a metal having work function $2W_0$?

(a)4λ (b)2 λ (c) λ/2 (d) λ/4

3.A proton and an α-particle have the same de Broglie wavelength. What is same for both of them?

(a) Mass (b) Energy (c) Frequency (d) Momentum

4. Wave theory of light could not explain

(a) interference (b) diffraction (c) reflection (d) photo electric effect

5.The photoelectric effect is based on conservation of

(a)momentum (b) energy (c) mass (d) angular momentum

6. In photoelectric effect, the number of photoelectrons emitted per second is proportional to

(a) intensity of incident beam (b) frequency of incident beam

(c) velocity of incident beam (d) work function of photocathode.

7. A photon will have less energy if its

(a) amplitude is higher (b) frequency is higher

(c) wave length is longer (d) wave length is shorter

8. Which of the following will have the least value of q/m

(a) Electron (b) Proton

(c) α-particle (d) ß-particle

9. When green light is incident on the surface of metal, it emits photo-electrons but there is no such emission with yellow colour light. Which one of the colour can produce emission of photo-electrons

(a) Orange (b)Red (c) Indigo (d)None of the above

10.If maximum velocity with which an electron can be emitted from a photo cell is $4x10^8$cm/sec, the stopping potential is (mass of electron = 9×10^{-31} kg)

(a) 30 volt (b)45 volt (c) 59 volt (d) Information is insufficient

11. A source of light is placed at a distance of 50 cm from a photo cell and the stopping potential is found to be V_0. If the distance between the light source and photo cell is made 25 cm, the new stopping potential will be :

(a) $V_0/2$ (b) V_0 (c) 4 V_0 (d) 2 V_0

12. Photoelectric emission occurs only when the incident light has more than a certain minimum

(a) power (b) wavelength (c) intensity (d) frequency

13. In photoelectric emission process from a metal of work function 1.8 eV, the kinetic energy of most energetic electrons is 0.5 eV. The corresponding stopping potential is

(a) 1.8 V (b) 1.3 V (c) 0.5 V (d) 2.3 V

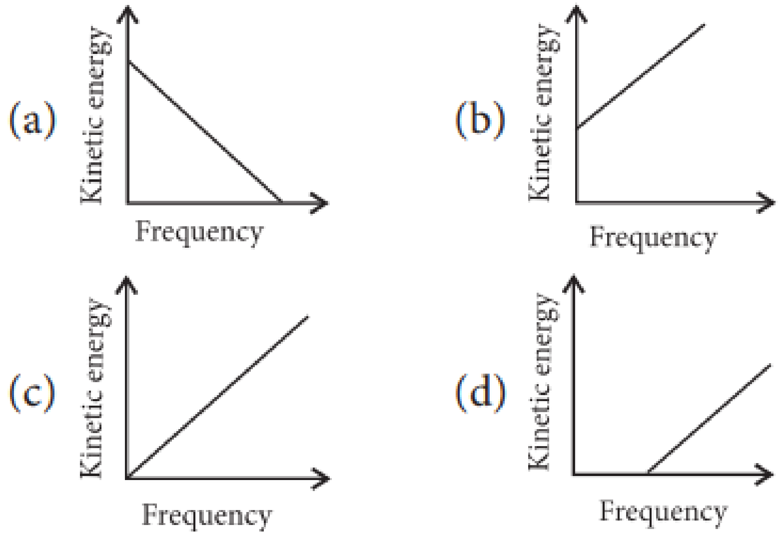
14. If the momentum of an electron is changed by P, then the de Broglie wavelength associated with it changes by 0.5%. The initial momentum of electron will be

(a) 200P (b) 400P (c) P/200 (d) 100P

15. Two radiations of photons energies 1 eV and 2.5 eV, successively illuminate a photosensitive metallic surface of work function 0.5 eV. The ratio of the maximum speeds of the emitted electrons is

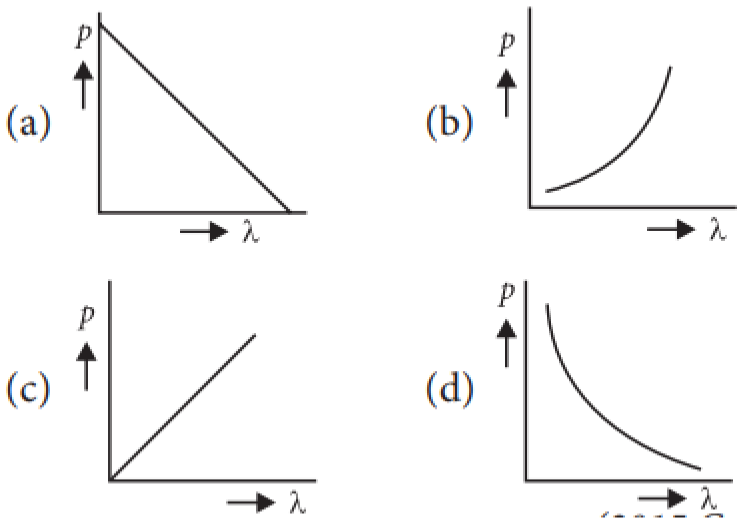
(a) 1 : 4 (b) 1 : 2 (c) 1 : 1 (d) 1 : 5

16. According to Einstein's photoelectric equation, the graph between the kinetic energy of photoelectrons ejected and the frequency of incident radiation is



17. Light of frequency 1.5 times the threshold frequency is incident on a photosensitive material. What will be the photoelectric current if the frequency is halved and intensity is doubled?
(a) Doubled (b) Four times (c) One-fourth (d) Zero

18. Which of the following figures represent the variation of particle momentum and the associated de-Broglie wavelength?



19.The threshold frequency for photoelectric effect on sodium corresponds to a wavelength of 5000 Å. Its work function is
(a) 4×10^{-19} J (b) 1 J (c) 2×10^{-19} J (d) 3×10^{-19} J

20. The threshold frequency for a photosensitive metal is 3.3×10^{14} Hz. If light of frequency 8.2×10^{14} Hz is incident on this metal, the cut-off voltage for the photoelectron emission is nearly
(a) 1 V (b) 2 V (c) 3 V (d) 5 V

ANSWER KEY for MCQs - Dual Nature of Radiation & Matter

1. (d) 2.(c) λ/2 3. (d) 4. (d) 5. (b) 6. (a) 7. (c)

8. (c) Mass of α-particle is maximum, so $\left(\frac{q}{m}\right)_{\alpha}$ is least

9. (c) Indigo. Wave length of green light is threshold wave length.
Hence for emission of electron, wave length of incident light < wavelength of green light.

10. (b) 45 volt
11. (b) : By changing the position of source of light from photo cell, there will be a change in the intensity of light falling on photo cell. As stopping potential is independent of the intensity of the incident light, hence stopping potential remains same i.e., V_o.
12. (d) : The photoelectric emission occurs only when the incident light has more than a certain minimum frequency. This minimum frequency is called threshold frequency.
13. (c) : The stopping potential Vs is related to the maximum kinetic energy of the emitted electrons Kmax through the relation Kmax = eVs
0.5 eV = eVs or Vs = 0.5 V
14. (a)
15. (b) 1 : 2
16. (d)
17. (d) No photoelectric emission will take place
18. (d) de-Broglie wavelength, $\lambda = h/p$. This represents a rectangular hyperbola.
19. (a) 4×10^{-19} J
20. (b) 2 V

ASSERTION- REASONING QUESTIONS- Dual Nature of Radiation & Matter

Directions:

In each of the following questions, a statement of Assertion (A) is given, followed by a corresponding statement of Reason(R) just below it. Of the statements, mark the correct answer as:
(A)If both assertion and reason are true and reason is the correct explanation of assertion
(B)If both assertion and reason are true but reason is not the correct explanation of assertion
(C)If assertion is true and reason is false
(D)If both assertion and reason are false

1. Assertion: A photon has no rest mass, yet it carries definite momentum.
Reason: Momentum of photon is due to its energy and hence its equivalent mass.
(a) A (b) B (c) C (d) D
2. Assertion: Photoelectric effect demonstrates the wave nature of light.
Reason: The number of photoelectrons is proportional to the frequency of light.
(a) A (b) B (c) C (d) D
3. Assertion: When light of certain wavelength falls on a metal surface it ejects electron.
Reason: Light has wave nature.
(a) A (b) B (c) C (d) D
4. Assertion: As work function of a material increases by some mechanism, it requires greater energy to excite the electrons from its surface.
Reason: A plot of stopping potential (V) versus frequency (v) for different materials, has greater slope for metals with greater work functions
(a) A (b) B (c) C (d) D
5. Assertion: Light of frequency 1.5 times the threshold frequency is incident on photosensitive material. If the frequency is halved and intensity is doubled the photo current remains unchanged.
Reason: The photo electric current varies directly with the intensity of light and frequency of light.

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

6. Assertion: The de-Broglie wavelength of a neutron when its kinetic energy is k is λ. Its wavelength is 2 λ when its kinetic energy is 4k.

   Reason: The de - Broglie wavelength λ is proportional to square root of the kinetic energy.

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

7. Assertion: On increasing the intensity of light, the number of photoelectrons emitted is more. Also the kinetic energy of each photon increases but the photoelectric current is constant.

   Reason: Photoelectric current is independent of intensity but increases with increasing frequency of incident radiation.

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

8. Assertion:The process of photoelectronic emission and thermionic emission of electrons are different.

   Reason: Photoelectric emission does not depend upon temperature, whereas thermionic emission is temperature dependent.

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

9. Assertion: When a photon of energy hν is incident on an electron in a metal of work function φ (more than hν) the electron will not necessarily come out of the metal.

   Reason: Work function is the minimum energy required to liberate an electron out of a metal. So some electrons may require more energy for their liberation.

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

10. Assertion: The photoelectric effect is a proof of the quantized nature of the light.

    Reason: Each photon in a light beam has same amount of energy.

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

(ASSERTION- REASONING - ANSWER KEY- Dual Nature of Radiation & Matter)

1. Correct answer: A
2. Correct Answer: D
3.Correct Answer: B
4.Correct Answer: C
5. Correct Answer: D
6. Correct answer: A 7. Correct Answer: D

   On increasing the intensity of light only number of photoelectrons increase and not the KE of electrons or photons.

8. Correct Answer: A

   The process of photoelectric emission depends on frequency of wave and thermionic emission occurs when metal is heated.

9. Correct answer: A
10. Correct Answer: C

    The assertion is correct but reason is completely false. It can only be true for a completely monochromatic laser beam.

CASE STUDY BASED QUESTIONS- Dual Nature of Radiation & Matter

CASE STUDY:1

Lenard observed that when ultraviolet radiations were allowed to fall on the emitter plate of an evacuated glass tube, enclosing two electrodes (metal plates), current started flowing in the circuit connecting the plates. As soon as the ultraviolet radiations were stopped, the current flow was also stopped. These observations proved that it was ultraviolet radiations, falling on the emitter plate, that ejected some charged particles from the emitter and the positive plate attracted them.

1) Alkali metals like Li, Na, K and Cs show photo electric effect with visible light but metals like Zn, Cd and Mg respond to ultraviolet light. Why?
   a) Frequency of visible light is more than that for ultraviolet light
   b) Frequency of visible light is less than that for ultraviolet light
   c) Frequency of visible light is same for ultraviolet light
   d) Stopping potential for visible light is more than that for ultraviolet light
2) Why do we not observe the phenomenon of photoelectric effect with non-metals?
   a) For non-metals the work function is high
   b) Work function is low
   c) Work function can't be calculated
   d) For non-metals, threshold frequency is low
3) What is the effect of increase in intensity on photoelectric current?
   a) Photoelectric current increases b) Decreases
   c) No change d) Varies with the square of intensity
4) Name one factor on which the stopping potential depends
   a) Work function b) Frequency
   c) Current d) Energy of photon
5) How does the maximum K.E. of the electrons emitted vary with the work function of metal?
   a) It doesn't depend on work function
   b) It decreases as the work function increases
   c) It increases as the work function increases
   d) Its value is doubled with the work function

ANSWERS

1) b. Frequency of visible light is less than that for ultraviolet light.
2) a. For non-metals, the work function is high.
3) a. Photoelectric current increases.
4) b. Frequency.
5) b. It decreases as the work function increases.

CASE STUDY:2

The discovery of the phenomenon of photoelectric effect has been one of the most important discoveries in modern science. The experimental observations associated with this phenomenon made us realize that our, 'till then', widely accepted picture of the nature of light – The electromagnetic (wave) theory of light – was quite inadequate to understand this phenomenon. A 'new picture' of light was needed and it was provided by Einstein through his 'photon theory' of light. This theory, regarded light as a stream of particles. Attempts to understand photoelectric effect thus led us to realize that light, which was being regarded as 'waves', could also behave like 'particles'. This led to the idea of 'wave-particle duality' vis-à-vis the nature of light. Attempts to understand this 'duality', and related phenomenon, led to far reaching, and very important developments, in the basic theories of Physics.

1) Which of the following phenomena explain the wave nature of light?
a) Interference b) Diffraction c) polarization d) all of them
2) Wave-particle duality is shown by
a) Light only b) matter only c) both light and matter d) None of them
3) The experiment to explain the wave nature of light i.e electromagnetic wave theory is given by
a) Hertz b) Einstein c) Lenard d) Huygen
4) The concept of photoelectric effect given by Einstein explains that the light is a
a) Photon b) Wave c) Particle d) Both
5) The practical application of the phenomenon of photoelectric effect and the concept of 'matter waves' is
a) Photocells b) Automatic doors at shops and malls
c) automatic light switches d) All of them

ANSWERS
1) d. all of them.
2) c. both light and matter.
3) a. Hertz
4) c. Particle
5) d. All of them.

UNIT- VIII: ATOMS & NUCLEI

Ch-12 : ATOMS

MCQs

1.The ratio between Bohr's radii is
(a) 1: 2: 3 (b) 2 : 4 : 6 (c) 1 : 4 : 9 (d) 1 : 3 : 5
2. In terms of Rydberg's constant R, the wave number of the first Balmer line is
(a) R (b) 3R (c) 5R/36 (d) 8R/9
3. The transition of electron from n = 4, 5, 6… to n = 3 corresponds to
(a) Lyman series (b) Paschen series (c) Balmer series (d) Brackett series
4. Which of the following spectral series in hydrogen atom gives spectral line of 4860 A?
(a) Lyman (b) Balmer (c) Paschen (d) Bracket
5. The transition from the state n = 5 to n = 1 in a hydrogen atom results in UV radiation. Infrared radiation will be obtained in the transition
(a) $2 \rightarrow 1$ (b) $3 \rightarrow 2$ (c) $4 \rightarrow 3$ (d) $6 \rightarrow 2$
6.Which of the following postulates of the Bohr model led to the quantization of energy of the hydrogen atom?
(a) The electron goes around the nucleus in circular orbits.
(b) The angular momentum of the electron can only be an integral multiple of $h/2\pi$.
(c) The magnitude of the linear momentum of the electron is quantized
(d) Quantization of energy is itself a postulate of the Bohr model.

7.The ratio of ionization energy of Bohr's hydrogen atom and Bohr's hydrogen like lithium atom is
(a)1 : 1 (b)1 : 3 (c)1 : 9 (d) None of these
8.What is the angular momentum of an electron in Bohr's hydrogen atom whose energy is – 0.544 eV.
(a) h/π (b) $2h/\pi$ (c) $5h/2\pi$ (d) $7h/2\pi$

9. The radius of inner most electron orbit of a hydrogen atom is “a”. The radius of n = 4 orbit is

(a) 4a (b) 8a (c) 12a (d) 16a

10. What is the ratio of radii of the orbits in a hydrogen atom in between n = 2 and n = 3 orbits?

(a) 4: 9 (b) 9: 4 (c) 2: 3 (d) 3: 2

ANSWER KEY for MCQs – ATOMS

1. (c) 1: 4 : 9, In Bohr’s atomic model, $r \alpha n^2$
2. (c) 5R/36
3. (b) In transition from $n_1 = 3$ and $n_2 = 4, 5, 6$…Infrared radiation of Paschen spectral line is emitted.
4. (b) Since spectral line of wavelength 4860 A, it lies in the visible region of the spectrum which is Balmer series of the spectrum.
5. (c) $4 \rightarrow 3$
6. (b) The angular momentum of the electron can only be an integral multiple of $h/2\pi$.
7. (c) 1: 9 8. (c) $5h/2\pi$ 9. (d) 16 a 10. (a) 4: 9

ASSERTION- REASONING QUESTIONS - ATOMS

Directions:

In each of the following questions, a statement of Assertion (A) is given, followed by a corresponding statement of Reason(R) just below it. Of the statements, mark the correct answer as:
(A)If both assertion and reason are true and reason is the correct explanation of assertion
(B)If both assertion and reason are true but reason is not the correct explanation of assertion
(C)If assertion is true and reason is false
(D)If both assertion and reason are false

1. Assertion: According to Bohr’s atomic model the ratio of angular momenta of an electron in first excited state and in ground state is 2:1.
   Reason: In a Bohr’s atom the angular momentum of the electron is directly proportional to the principal quantum number.
   (a) A (b) B (c) C (d) D
2. Assertion:The force of repulsion between atomic nucleus and α-particle varies with distance according to inverse square law.
   Reason: Rutherford did α-particle scattering experiment.
   (a) A (b) B (c) C (d) D
3. Assertion: The positively charged nucleus of an atom has a radius of almost $10{-}15$m.
   Reason: In a-particle scattering experiment, the distance of closest approach for particles is $\simeq 10{-}15$m.
   (a) A (b) B (c) C (d) D
4. Assertion: Electrons in the atom are held due to coulomb forces
   Reason: The atom is stable only because the centripetal force due to Coulomb’s law is balanced by the centrifugal force.
   (a) A (b) B (c) C (d) D
5. Assertion: For the scattering of α -particles at large angles, only the nucleus of the atom is responsible.
   Reason: Nucleus is very heavy in comparison to α-particles.
   (a) A (b) B (c) C (d) D

(Assertion- Reasoning - ANSWER KEY- Atoms)

1. Correct answer: A
2. Correct Answer: B

   Rutherford confirmed the repulsive force on α-particle due to nucleus varies with distance according to inverse square law and that the positive charges are concentrated at the centre and not distributed throughout the atom.
3. Correct Answer: A

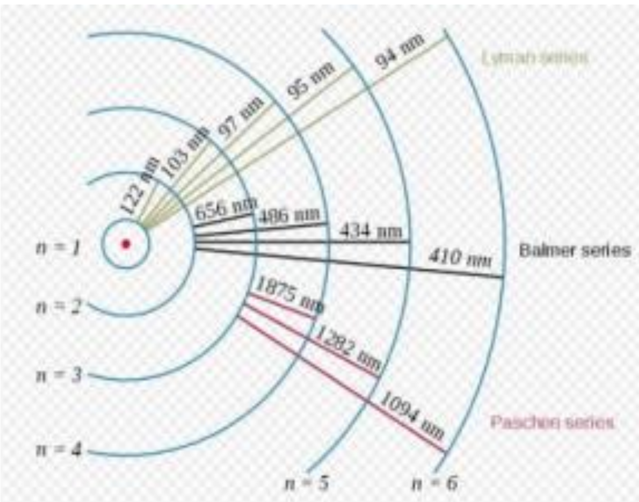
   In a-particle scattering experiment, Rutherford found a small number of particles which were scattered back through an angle approaching to 180∘. This is possible only if the positive charges are concentrated at the centre or nucleus of the atom.
4. Correct Answer: C

   According to postulates of Bohr's atom model, the electron revolves around the nucleus in fixed orbit of definite radii. As long as the electron is in a certain orbit it does not radiate any energy.
5. Correct Answer: A

   We know that an electron is very light particle as compared to an alpha particle. Hence electron cannot scatter the α-particle at large angles, according to law of conservation of momentum. On the other hand, mass of nucleus is comparable with the mass of α-particle, hence only the nucleus of atom is responsible for scattering of α-particles.

CASE STUDY:3 FROM Ch:12 - ATOMS

Spectral emission occurs when an electron transitions, or jumps, from a higher energy state to a lower energy state. To distinguish the two states, the lower energy state is commonly designated as n1, and the higher energy state is designated as n2. The energy of an emitted photon corresponds to the energy difference between the two states. Because the energy of each state is fixed, the energy difference between them is fixed, and the transition will always produce a photon with the same energy.



1. The wavelength of Lyman series lies in
   (a) ultraviolet region (b) infrared region
   (c) far infra-red region (d) visible region
2. Energy correspond to second excited state is
   (a) - 3.4 eV (b) -0.85 eV (c) -1.51 eV (d) -2.51 eV

3.When an electron in an atom jumps from a higher orbit to lower orbit, its
(a) kinetic energy increases, potential energy decreases
(b) kinetic energy remains same, potential energy decreases
(c) kinetic energy increases, potential energy remains same
(d) kinetic energy increases, potential energy increases

4. The ratio of the speed of the electron in vacuum to speed of light in the first excited state of hydrogen atom is
(a) 1 /137 (b) 2 /137 (c) 137 (d) 137/ 2

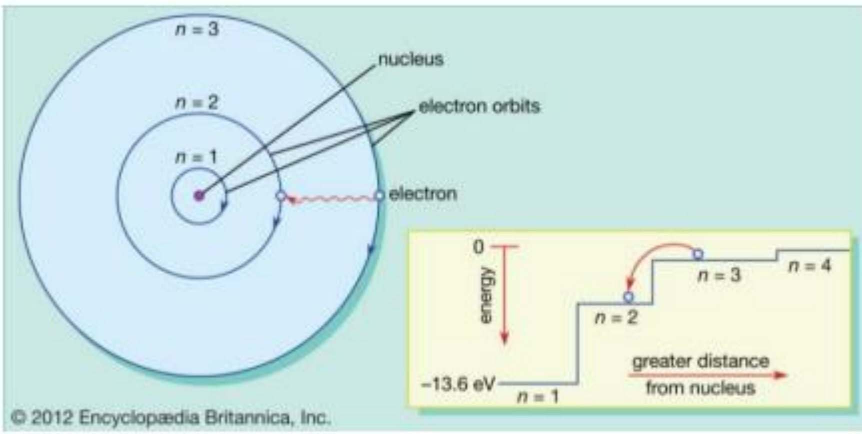
5. The wavelength limit present in the Brackett series is (R = 1.097 × 107 m^{-1})
(a) 1458 nm (b) 1898 nm (c) 2278 nm (d) 2535 nm

ANSWERS

1. (a) ultraviolet region 2. (c) -1.51 eV
3. (a) kinetic energy increases, potential energy decreases
4. (d) 137 /2 5. (a) 1458 nm

CASE STUDY:4 FROM Ch:12 ATOMS

Bohr's Atomic Model Bohr model describes the atom as a positively charged nucleus, which is surrounded by electrons. When electrons travel in circular orbits, attraction is provided by electrostatic forces. Normally occupied energy level of the electron is called the ground state. The electron can move to the less – stable level by absorbing energy. This higher – energy level is called excited state. The electron can return to its original level by releasing the energy. All in all, when electron jumps between orbits, it is accompanied by an emitted or absorbed amount of energy (hν).



1. According to Bohr's model of hydrogen atom, the path of the electron revolving round the proton is
(a)An ellipse (b) a circle of any radius
(c) a circle of constantly decreasing radius (d) a circle of an allowed radius

2. In Bohr's model, the radius of the first orbit is r, then the radius of fourth orbit is
(a) r (b) 4r (c) 16r (d) r/16

3. The kinetic energy of the electron in an orbit of radius r in hydrogen atom is proportional to
(a) e^2/r (b) e^3/r (c) $e^2/2r$ (d) $e^2/2r^2$

4. In H atom, an electron orbiting has energy level -3.4eV.Its angular momentum will be
(a) 2.1 x 10^{20} J s (b) 2.1 x 10^{-34} J s (c) 4.2 x 10^{20} J s (d) 4.2 x 10^{-34} J s

5. Bohr's theory of hydrogen atom did not explain fully
(a) diameter of H-atom (b) emission of spectra
(c) ionization energy (d) the fine structure of hydrogen spectrum

ANSWERS

1. (d) a circle of an allowed radius 2. (c) 16r
3. (c) e 2/2r 4. (b) 2.1 x 10-34 J s 5. (d) the fine structure of hydrogen spectrum.

Ch.13 - NUCLEI

MCQs

1. The radius of a nucleus is
(a) directly proportional to its mass number
(b) inversely proportional to its atomic weight
(c) directly proportional to the cube root of its mass number
(d) None of these
2. A neutron can cause fission in
(a) Hydrogen (b) Uranium – 235 (c) Thorium (d) Uranium – 238
3. One milligram of matter converted into energy, will give
(a) 9 Joule (b) 9×10^3 Joule (c) 9×10^5 Joule (d) 9×10^{10} Joule
4. Two spherical nuclei have mass numbers 216 and 64 with their radii R_1 and R_2 respectively.
The ratio, R_1/ R_2 is equal to
(a) 3 : 2 (b)1 : 2 (c) 1 : 3 (d) 2 : 3
5. Which of the following statements is true for nuclear forces?
(a) They obey the inverse square law of distance
(b)They obey the inverse third power law of distance
(c) They are short range forces
(d) They are equal in strength to electromagnetic forces
6. Fusion reaction of hydrogen takes place at high temperature because
(a) Nuclei break up at high temperature
(b) Atoms gets ionised at high temperature
(c) Kinetic energy is high enough to overcome the coulomb repulsion between nuclei
(d) Ignition temperature of hydrogen is very high.
7. A nuclear fission is said to be critical when multiplication factor or K
(a) K = 1 (b) K > 1 (c) K < 1 (d) K = 0
8. If PP, NN and PN are the nuclear forces between proton and proton, between neutron and neutron and between proton and neutron, then
(a) PP =NN =PN
(b) PP> NN> PN
(c) PP< NN< PN
(d) PP< NN > PN

9. If the radius of the $^{27}Al_{13}$ nucleus is taken to be R_{Al}, then the radius of $^{125}Te_{53}$ nucleus is nearly

a) $(\frac{3}{5})R_{Al}$
b) $(\frac{13}{53})^{1/3}R_{Al}$

c) $(\frac{53}{13})^{1/3}R_{Al}$

d) $(\frac{5}{3})\ R_{Al}$

10. What is the ratio of nuclear radii if the mass numbers of two nuclei are 4 and 32?

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

ANSWER KEY for MCQs – NUCLEI

1. (c) directly proportional to the cube root of its mass number
2. (b) Uranium – 235
3. (d) 9 x 10^{10} Joule
4. (a) 3 : 2
5. (c) They are short range forces
6. (d) Ignition temperature of hydrogen is very high.
7. (a) K = 1
8. (a) PP =NN =PN
9. (d) $(\frac{5}{3})R_{Al}$
10. (a)1: 2

ASSERTION- REASONING QUESTIONS - NUCLEI

Directions:

In each of the following questions, a statement of Assertion (A) is given, followed by a corresponding statement of Reason(R) just below it. Of the statements, mark the correct answer as:

(A)If both assertion and reason are true and reason is the correct explanation of assertion

(B)If both assertion and reason are true but reason is not the correct explanation of assertion

(C)If assertion is true and reason is false

(D)If both assertion and reason are false

1. Assertion: Fast moving neutrons do not cause fission of a uranium nucleus.
   Reason: A fast moving neutron spends very little time inside the nucleus.
   (a) A (b) B (c) C (d) D
2. Assertion: Nuclear density is almost same for all nuclei.
   Reason: The radius (r) of a nucleus depends only on the mass number (A) as r ∝ A1/3.
   (a) A (b) B (c) C (d) D
3. Assertion: Mass is not conserved, but mass and energy as a single entity called mass-energy.
   Reason: Mass and energy are inter-convertible in accordance with Einstein’s relation, $E = mc^2$
   (a) A (b) B (c) C (d) D
4. Assertion: Two protons can attract each other inside the nucleus.
   Reason: The distance between the protons within the nucleus is about 10-15 m.
   (a) A (b) B (c) C (d) D
5. Assertion: The nuclear force becomes weak if the nucleus contains too many protons compared to neutrons.
   Reason: The electrostatic forces weaken the nuclear force.
   (a) A (b) B (c) C (d) D

(ASSERTION- REASONING - ANSWER KEY- NUCLEI)

1. A 2.:A 3.: A 4.: A 5.: C

CASE STUDY: 5 from Ch-13 NUCLEI

Neutrons and protons are identical particles in the sense that their masses are nearly the same and the force, called nuclear force, does into distinguish them. Nuclear force is the strongest force. Stability of nucleus is determined by the neutron proton ratio or mass defect or packing fraction. Shape of nucleus is calculated by quadruple moment and spin of nucleus depends on even and odd mass number. Volume of nucleus depends on the mass number. Whole mass of the atom (nearly 99%) is centred at the nucleus.

(1) The correct statements about the nuclear force is/are
(a) charge independent (b) short range force
(c) non-conservative force (d) all of these.

(2) The range of nuclear force is the order of
(a) 2×10^{-10}m (b) 1.5×10^{-20}m (c) 1.2×10^{-4} m (d) 1.4×10^{-15} m

(3) A force between two protons is same as the force between proton and neutron. The nature of the force is
(a) electrical force (b) weak nuclear force
(c) gravitational force (d) strong nuclear force

(4) Two protons are kept at a separation of 40 A0. Fn is the nuclear force and Fe is the electrostatic force between them. Then
(a) Fn<<Fe (b) Fn= Fe (c) Fn>> Fe (d) Fn ≈ Fe

(5) All the nucleons in an atom are held by
(a) nuclear forces (b) Van der Wall's forces
(c) tensor forces (d) Coulomb forces

ANSWERS

(1) d
Explanation: All options are basic properties of nuclear forces. So, all options are correct.
(2) d
Explanation: The nuclear force is of short range and the range of nuclear force is the order of 1.4×10^{-14}m.
(3) d. strong nuclear force
(4) c. Fn>> Fe
(5) a. nuclear forces

UNIT-IX: ELECTRONIC DEVICES

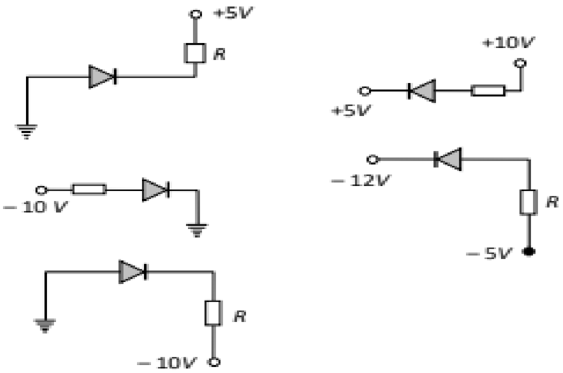
Ch–14: Semiconductor Electronics: Materials, Devices and Simple Circuits

MCQs

1. Which of the following statement is not true?
   a) The resistance of intrinsic semiconductor decreases with increase of temperature.
   b) Doping pure Si with trivalent impurity gives p-type semiconductor
   c) The majority carriers in n-type semiconductors are holes
   d) A p-n junction can act as a semiconductor diode.
2. P-type semiconductor is formed when
   (i) As impurity is mixed in Si (iii) B impurity is mixed in Ge
   (ii) Al impurity is mixed in Si (iv) P impurity is mixed in Ge

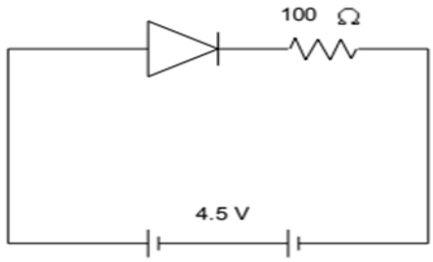
a) (i) and (iii) b) (i) and (iv)
c) (ii) and (iii) d) (ii) and (iv)

3. In the following figure which of the diodes are forward biased



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

4. Figure shows a diode connected to an external resistance and an emf. Assuming that the barrier potential developed in diode is 0.5V, obtain the value of current in the circuit in milli ampere.



a) 40mA
b) 60mA
c) 80mA
d) 100mA

5. The rectifier in which the rectified output is only for half of the input AC wave is called as___
a) full wave rectifier b) half wave rectifier
c) transformer d) transducer

6. It is given $n_e = 7 \times 10^{11}\ per\ metre^3$ and $n_h = 5 \times 10^{12}\ per\ metre^3$. The semiconductor is
a) P-type b) intrinsic c) n-type d) insulator

7. At which temperature, a pure semiconductor behaves slightly as a conductor?
a) Low temperature c) high temperature
b) Room temperature d) both (a) and (b)

8. The impurity atom, with which pure silicon should be doped to make a p-type semiconductor, are those of
a) Phosphorous b) boron c) antimony d) iron

9. If the forward voltage in a diode is increased, the width of the depletion region
a) Increases b) decreases c) fluctuates d) no change

Assertion and Reasoning type Questions

Two statements are given –one labelled Assertion (A) and other labelled Reason (R). Select the correct answer to these questions from the options as given below.
a) If both Assertion and Reason are true and Reason is correct explanation of Assertion.
b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
c) If Assertion is true but Reason is false.
d) If both Assertion and Reason are false.

10. **Assertion(A) :** Silicon is preferred over germanium for making semiconductor devices.
Reason (R): The energy gap in germanium is more than the energy gap in silicon.

11. **Assertion (A) :** A pure semiconductor has negative temperature coefficient of resistance.
Reason (R) : In a semiconductor on raising the temperature, more charge carriers are released, conductance increases and resistance decreases.

12. **Assertion :** When two semi conductor of p and n type are brought in contact, they form p-n junction which act like a rectifier.
Reason : A rectifier is used to convent alternating current into direct current.

13. **Assertion (A) :** The diffusion current in a p-n junction is from the p-side to the n-side.
Reason (A) : The diffusion current in a p-n junction is greater than the drift current when the

junction is in forward biased.

14. Assertion (A): The ratio of free electrons to holes in intrinsic semiconductor is greater than one.

    Reason (R) : the electrons are more mobile as compared to .

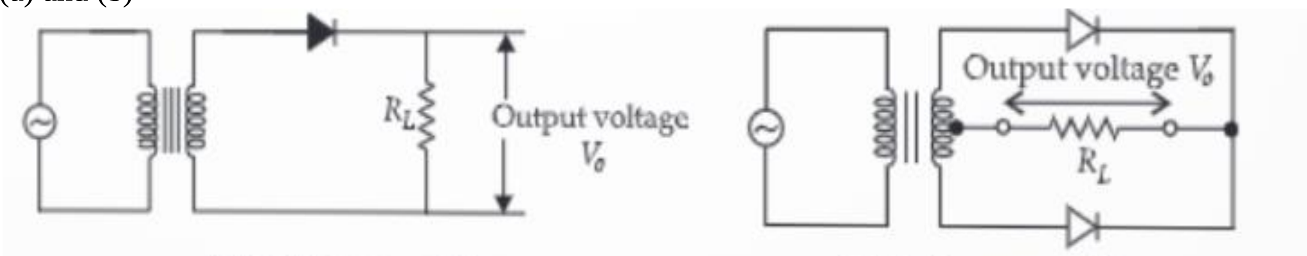
15. Assertion (A) : Putting p type semiconductor slab directly in physical contact with n type semiconductor slab cannot form the p-n junction.

    Reason (R) : The roughness at contact will be much more than inter atomic crystal spacing and continuous flow of charge carriers is not possible.

CASE STUDY BASED QUESTIONS

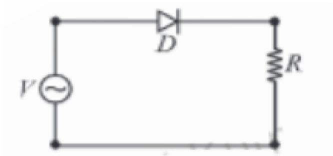
Read the following paragraph and answer the questions that follow

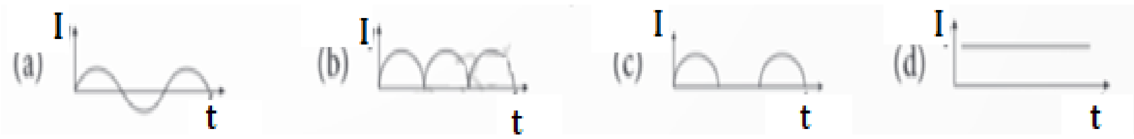
16. Rectifier: Rectifier is a device which is used for converting alternating current or voltage into direct current or voltage. Its working is based on the fact that the resistance of p-n junction becomes low when forward biased and becomes high when reverse biased. A half-wave rectifier uses only single diode while a full wave rectifier uses two diodes as shown in figures (a) and (b)



(a) Half wave rectifier (b) Full wave rectifier

(i) A p-n junction (D) shown in the figure can act as a rectifier. An alternating current source (V) is connected in the circuit. The current (I) in the resistor (R) can be shown by





(ii) With an ac input from 50 Hz power line, the ripple frequency is

a) 50 Hz in the dc output of half wave as well as full wave rectifier

b) 100 Hz in the dc output of half wave as well as full wave rectifier

c) 50 Hz in the dc output of half wave and 100 Hz in the dc output of full wave rectifier.

d) 100 Hz in the dc output of half wave and 50 Hz in the dc output of full wave rectifier

(iii) If the **rms** value of sinusoidal input to a full wave rectifier is $\frac{V_o}{\sqrt{2}}$ then the **rms** value of the rectifier's output is

(a) $\frac{V_0}{\sqrt{2}}$ (b) $\frac{V_0^2}{\sqrt{2}}$ (c) $\frac{V_0^2}{2}$ (d) $\sqrt{2}V_0^2$

(iv) An alternating current can be converted into direct current by a

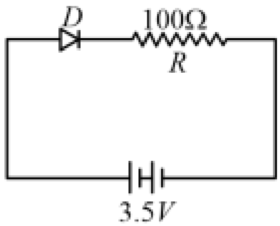
a) Dynamo b) Motor c) Transformer d) Rectifier

(v) The rectifier in which the rectified output is only for half of the input AC wave is called as___

a) full wave rectifier b) half wave rectifier

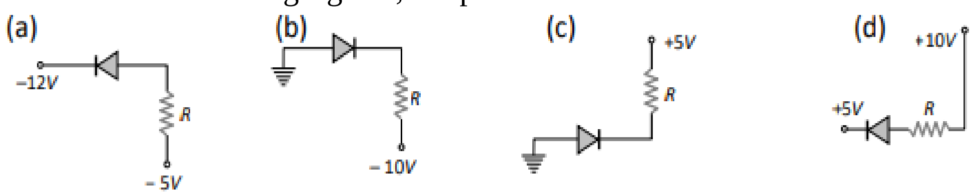
c) transformer d) transducer

17. A semiconductor diode is basically a p-n junction with metallic contacts provided at the ends for the application of an external voltage. It is a two terminal device. When an external voltage is applied across a semiconductor diode such that p-side is connected to the positive terminal of the battery and n-side to the negative terminal, it is said to be forward biased. When an external voltage is applied across the diode such that n-side is positive and p-side is negative, it is said to be reverse biased. An ideal diode is one whose resistance in forward biasing is zero and the resistance is infinite in reverse biasing. When the diode is forward biased, it is found that beyond forward voltage called knee voltage, the conductivity is very high. When the biasing voltage is more than the knee voltage the potential barrier is overcome and the current increases rapidly with increase in forward voltage. When the diode is reverse biased, the reverse bias voltage produces a very small current about a few microamperes which almost remains constant with bias. This small current is reverse saturation current.



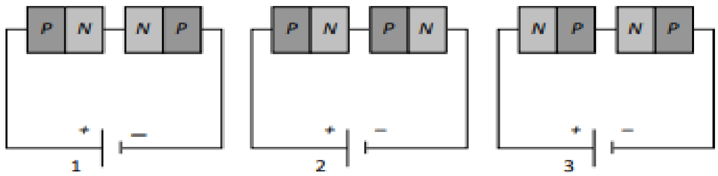
(i) In the given figure, a diode D is connected to an external resistance R = 100Ω and an emf of 3.5V. If the barrier potential developed across the diode is 0.5 V, the current in the circuit will be:
a) 40mA b) 20mA
c) 35mA d) 30mA

(ii) In which of the following figures, the p-n diode is reverse biased?



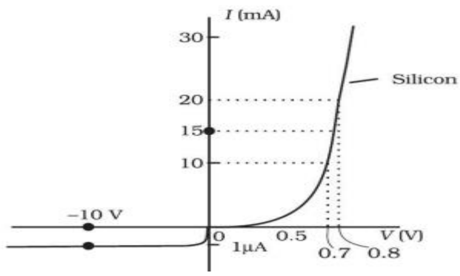
(iii) Based on the V-I characteristics of the diode, we can classify diode as
(a) bilateral device (b) Ohmic device (c) non-Ohmic device (d) passive element

(iv) Two identical PN junctions can be connected in series by three different methods as shown in the figure. If the potential difference in the junctions is the same, then the correct connections will be



(a) in the circuits (1) and (2) (b) in the circuits (2) and (3)
(c) in the circuits (1) and (3) (d) only in the circuit (1)

(v) The V-I characteristic of a diode is shown in the figure. The ratio of the resistance of the diode at I = 15 mA to the resistance at V = -10 V is
(a) 100 (b) 10^6
(c) 10 (d) 10^{-6}



18. Doping of p-n junction: p-n junction is a single crystal of Ge or Si doped in such a manner that one half portion of it acts as p-type semiconductor and other half functions as n-type semiconductor. As soon as a p-n junction is formed, the holes from the p-region diffuse into the n-region and electron from n region diffuse in to p-region. This results in the development of V_B across the junction which opposes the further diffusion of electrons and holes through the junction.

(i) In an unbiased p-n junction electrons diffuse from n-region to p-region because

a) Holes in p-region attract them
b) Electrons travel across the junction due to potential difference.
c) Electron concentration in n-region is more as compared to that in p-region
d) Only electrons move from n to p region and not the vice-versa

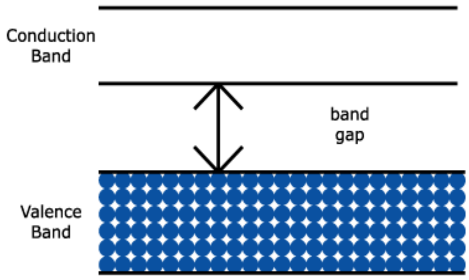
(ii) Electron hole recombination in p-n junction may lead to emission of
a) Light b) ultraviolet rays c) sound d) radioactive rays

(iii) In an unbiased p-n junction
a) Potential at p is equal to that at n
b) Potential at p is +ve and that at n is –ve
c) Potential at p is more than that at n
d) Potential at p is less than that at n

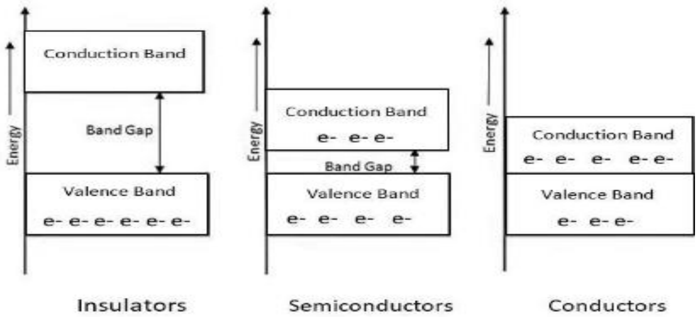
(iv) The potential of depletion layer is due to
a) Electrons b) holes c) ions d) forbidden band

(v) In the depletion layer of unbiased p-n junction,
a) It is devoid of charge carriers c) has only holes
b) Has only electrons d) p-n junction has a weak electric field.

19. Energy bands in solids: In case of isolated atoms, there are discrete energy levels. Inside a solid crystal, each electron has a different energy level because of slightly different patterns of the surrounding charges. These electron energy levels form a continuous energy variation called as the Energy Bands. Energy bands of more tightly bound electrons have lower energy (more negative energy) as compared to that of loosely bound electrons. When we take a solid as a whole there are bonds between atoms. For a particular atom in the solid, neighbouring atoms influence the energies of the outer electrons. These discrete levels spread into continuous bands of energies.



Valence band is the energy band consisting of valence (tightly-bound) electrons.
Conduction band is the energy band consisting of conduction (loosely-bound) electrons .
Valence band and conduction band are usually separated by forbidden energy gap. In case of metallic conductors, valence band overlaps conduction band and electrons are readily available for conduction. Hence they are good conductors. In case of insulators, there is large energy gap between valance band and conduction band. Therefore, conductivity is negligible. In case of semiconductors, the energy gap is small and at room temperature some of the electrons of valence band cross the energy gap and reach the conduction band to contribute some electrical conductivity.



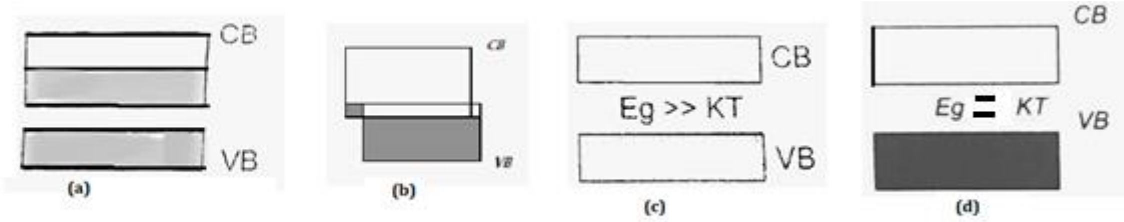
(i) In semiconductors at room temperature
a) The valence band is partially empty and the conduction band is partially filled.
b) The valence band is completely filled and the conduction band is partially filled.
c) The valence band is completely filled
d) The conduction band is completely empty.

(ii) In insulators
a) Valance band is partially filled with electrons
b) Conduction band is partially filled with electrons
c) Conduction band is filled with electrons and valence band is empty.
d) Conduction band is empty and valence band is completely filled with electrons.

(iii) In an insulator , the forbidden energy gap between a valence band and conduction band is of the order of

a) 1MeV b) 1 keV c) 1 eV d) 5 eV

(iv) Which of the energy band diagrams shown in the figure corresponds to that of a semiconductor?



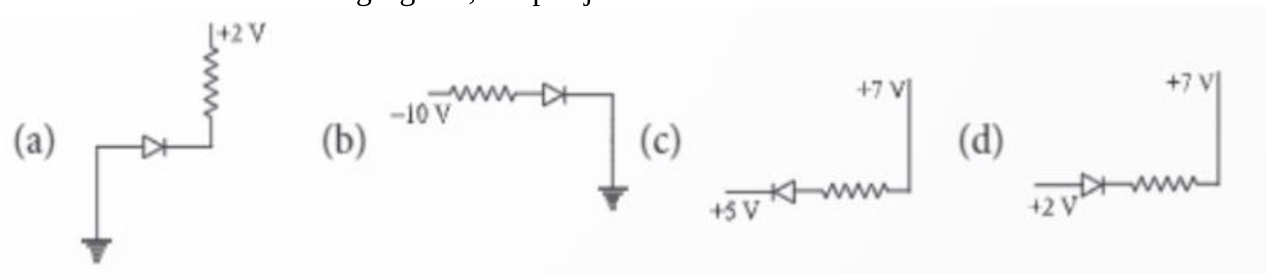
(v) In germanium crystal. The forbidden energy gap in joule is

a) 1.6×10^{-19} b) zero c) 1.12×10^{-19} d) 1.76×10^{-19}

20. Biasing of diode: When the diode is forwarded biased, it is found that beyond forward voltage V= V_k, called knee voltage, the conductivity is very high. At this value of battery biasing for p-n junction, the potential barrier is overcome and the current increases rapidly with increase in forward voltage.

When the diode is reverse biased, the reverse bias voltage produces a very small current about a few microamperes which almost remains constant with bias. This small current is reverse saturation current.

(i) In which of the following figures, the p-n junction is forward biased?

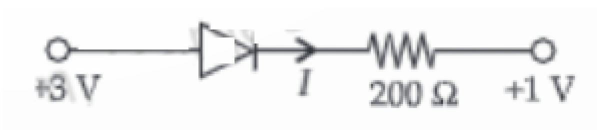


(ii) In case of forward biasing of a p-n junction diode, which one of the following figures correctly depicts the direction of conventional current (indicated by an arrow mark)?

(iii) If an ideal junction diode is connected as shown, then the value of the current I is

a) 0.013A b) 0.02A

c) 0.01A d) 0.1A



(iv) In order to forward bias a p-n junction, the negative terminal of battery is connected to

a) p-side b) n-side c) either p-side or n-side d) None of these

(v) Which of the following statement is not correct when a junction diode is in forward bias?

a) The width of depletion region decreases.
b) Free electrons on n-side will move towards the junction.
c) Holes on p-side move towards the junction.
d) Electrons on n-side and holes on p-side will move away from junction.

(vi) A p-type material is electrically ….

a) Positive b) Negative
c) Neutral d) Depends on the concentration of p impurities

ANSWER KEY - Semiconductor devices

Q.No.	ANSWER/ STEPS
1	C) The majority carriers in n-type semiconductors are holes
2	c) (ii) and (iii)
3	b) 2,4,5
4	a) 40mA Apply Kirchhoff's voltage law in the circuit, 4.5 = 0.5 + 100I 100I = 4 I=4/100= 40mA
5	b) half wave rectifier
6	a) P-type As $n_e < n_h$
7	b) Room temperature
8	b) boron
9	b) decreases
10	C
11	a
12	b
13	b
14	b
15	a
16	(i) C (ii) C) 50 Hz in the dc output of half wave and 100 Hz in the dc output of full wave rectifier. (iii) a) $\frac{V_o}{\sqrt{2}}$ (iv) d) Rectifier (v) b) half wave rectifier
17	(i) d) 30mA (ii) c) (iii) (c) non-Ohmic device (iv) (b) in the circuits (2) and (3) (v) (d) 10^{-6} Resistance of diode in forward bias is given by $R_f = \frac{\Delta V}{\Delta I} = \frac{0.1V}{10mA}$ Resistance of diode in reverse bias is given by $R_r = \frac{V}{I} = \frac{10V}{1\mu A}$ So $\frac{R_f}{R_r} = 10^{-6}$
18	(i) a) Electron concentration in n-region is more as compared to that in p-region (ii) a) Light (iii) d) Potential at p is less than that at n (iv) d) forbidden band (v) a) It is devoid of charge carriers
19	(i) a) The valence band is partially empty and the conduction band is partially filled. (ii) d) Conduction band is empty and valence band is completely filled with

		electrons.
	(iii)	d) 5 eV
	(iv)	d)
	(v)	c) 1.12 $x10^{-19}$
20	(i)	c)
	(ii)	d)
	(iii)	c) 0.01A for ideal diode in forward bias it offers **zero** resistance. Hence her resistance of circuit is 200Ω Potential difference = 3V – 1V =2V So, current = V/R = 2V/200Ω = 0.01A
	(iv)	b) n-side
	(v)	d) Electrons on n-side and holes on p-side will move away from junction.
	(vi)	c) Neutral

IMPORTANT FORMULAE IN ELECTROSTATICS

1. Electrostatic force between two charges

$$F = k\frac{q_1 q_2}{r^2} = \{\frac{1}{4\pi\epsilon_0\epsilon_r}\}\frac{q_1 q_2}{r^2}$$

For air, $\epsilon_r = 1$

$F_{air} = \frac{1}{4\pi\epsilon_0} . \frac{q_1 q_2}{r^2} = 9 \times 10^9 \ \frac{q_1 q_2}{r^2}$

2. Electric field intensity due to a point charge, $\vec{E} = \lim_{q_0 \to 0} \frac{\vec{F}}{q_o}$
3. Electric field intensity due to infinite linear charge density (λ)

$E = \frac{1}{4\pi\epsilon_0} . \frac{2\lambda}{r}$

4. Electric field intensity near an infinite thin sheet of surface charge density σ

$E = \frac{\sigma}{2\epsilon_0}$

For thick sheet, $E = \frac{\sigma}{\epsilon_0}$.

5. Electric potential, $V = \lim_{q_0 \to 0} \frac{W}{q_o}$

Electric potential due to a point charge, $V = \frac{1}{4\pi\epsilon_0} . \frac{q}{r}$

6. Relation between electric field and potential, $E = -\frac{dV}{dr} = \frac{V}{r}$ (numerically)
7. Dipole moment, $\vec{p} = q . 2\vec{l}$
8. Torque on a dipole in uniform electric field, $\vec{\tau} = \vec{p} \times \vec{E}$.
9. Potential energy of dipole, $U = -\vec{p}.\vec{E} = -pE\cos\theta$
10. Work done in rotating the dipole in uniform electric field from orientation θ_1 to θ_2 is

$W = U_2 - U_1 = pE(\cos\theta_1 - \cos\theta_2)$

11. Electric field due to a short dipole

(i) at axial point, $E_{axis} = \frac{1}{4\pi\epsilon_0} . \frac{2p}{r^3}$

(ii) at equatorial point, $E_{equatorial} = \frac{1}{4\pi\epsilon_0} . \frac{p}{r^3}$

12. Electric potential due to a short dipole

(i) At axial point, $V_{axis} = \frac{1}{4\pi\epsilon_0} . \frac{p}{r^2}$

(ii) At equatorial point, $V_{equatorial} = 0$.

13. Dielectric constant, $k = \frac{\epsilon}{\epsilon_0} = \frac{C_{med}}{C_{air}}$
14. Capacitance of parallel plate capacitor

(i) $C = \frac{A\epsilon_0 K}{d}$, in medium of dielectric constant k

(ii) $C = \frac{A\epsilon_0}{d - t(1 - \frac{1}{K})}$; if space between plate partially filled with dielectric of thickness t.

15. Combination of capacitors :-

(i) In series, $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$, $q_1 = q_2 = q_3$, $V = V_1 + V_2 + V_3$

(ii) In parallel, $C = C_1 + C_2 + C_3$, $q = q_1 + q_2 + q_3$, $V_1 = V_2 = V_3 = V$

16. Energy stored by capacitor

$U = \frac{1}{2}CV^2 = \frac{Q^2}{2C} = \frac{1}{2}QV$

17. Electrostatic energy density

$u_o = \frac{1}{2}\epsilon_0 E^2$, in air

$u = \frac{1}{2}\epsilon E^2$, in medium

Important Formulae- Current Electricity

1. Electric current = $\frac{Charge}{Time}$ or $\mathbf{I = \frac{q}{t} = \frac{ne}{t}}$

2. In case of an electron revolving in a circle of radius **r** with speed **v**, period of revolution is $\mathbf{T = \frac{2\pi r}{v}}$

   Frequency of revolution, $\boldsymbol{\nu = \frac{1}{T} = \frac{v}{2\pi r}}$ Current, $\mathbf{I = e\,\nu = \frac{ev}{2\pi r}}$

3. Ohm's law, $V \propto I$ or $V = RI$ or $R = \frac{V}{I}$

4. Current in terms of drift velocity (v_d) is $\mathbf{I = n\,e\,A}\boldsymbol{v_d}$

5. Resistance of a uniform conductor, $R = \rho\frac{l}{A} = \frac{ml}{ne^2\tau A}$

6. Resistivity or specific resistance, $\boldsymbol{\rho = \frac{RA}{l} = \frac{m}{ne^2\tau}}$

7. Conductance = $\frac{1}{R}$

8. Conductivity = $\frac{1}{Resistivity}$ or $\boldsymbol{\sigma = \frac{1}{\rho} = \frac{l}{RA}}$

9. Current density = $\frac{Current}{Area}$ or $\mathbf{j = \frac{I}{A} = en}\boldsymbol{v_d}$

10. Relation between current density and electric field, $\mathbf{j = \sigma E}$ or $E = \rho\,j$

11. Mobility $\boldsymbol{\mu = \frac{v_d}{E}}$

12. Temperature coefficient of resistance, $\boldsymbol{\alpha = \frac{R_2 - R_1}{R_1(t_2 - t_1)}}$

13. The equivalent resistance $\boldsymbol{R_s}$ of a number of resistances connected in series is $\boldsymbol{R_s = R_1 + R_2 + R_3 + \ldots}$

14. The equivalent resistance $\boldsymbol{R_p}$ of a number of resistances connected in parallel is given by

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots.$$

15. emf of a cell, $\boldsymbol{\varepsilon = \frac{W}{q}}$

16. For a cell of internal resistance **r**, the emf is $\mathbf{\varepsilon = V + I\,r = I\,(R + r)}$

17. Terminal p.d of a cell, $\mathbf{V = I\,R = \frac{\varepsilon R}{R+r}}$

18. Terminal p.d. when a current is being drawn from the cell, $\mathbf{V = \varepsilon - I\,r}$

19. Terminal p.d. when the cell is being charged, $\mathbf{V = \varepsilon + I\,r}$

20. Internal resistance of a cell, $\mathbf{r = R\,[\frac{\varepsilon - V}{V}]}$

21. For **n** cell in series, $\mathbf{I = \frac{nE}{R+nr}}$

22. For **n** cells in parallel, $\mathbf{I = \frac{n\varepsilon}{nR+r}}$

23. Heat produced by electric current, $H = I^2Rt$ joule $= \frac{I^2Rt}{4.18}$ cal

24. Electric power, $\mathbf{P = \frac{W}{t} = VI = \mathit{I}^2R = \frac{V^2}{R}}$

Important Formulae-Magnetic effects of current & magnetism

- Biot-Savart law (Magnetic field due to current element)

$$dB = \frac{\mu_0}{4\pi}\frac{I\,dl\sin\theta}{r^2}$$

- Force acting on a charge moving in a magnetic field

$F = qvB\sin\theta$ or $\vec{F} = q(\vec{v}\times\vec{B})$

- Magnetic field on the axis of a circular current loop

$$B = \frac{\mu_0 N I a^2}{2(r^2+a^2)^{3/2}}.$$

- Magnetic field due to an infinitely long straight current carrying wire

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

- Magnetic field at a point on the axis of a solenoid

$$B = \mu_0 nI$$

- Motion of a charged particle in a uniform magnetic field

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

- Torque on a rectangular coil in a uniform magnetic field

$\tau = NIBA\sin\theta$

- Force per unit length acting on each of the two straight parallel metallic conductors carrying current

$$f = \frac{F_2}{l} = \frac{\mu_0 I_1 I_2}{2\pi r}$$

- Deflection in moving coil galvanometer

$$\alpha = \frac{NBAI}{k}$$

- Conversion of galvanometer into ammeter and voltmeter

$S = \frac{I_g G}{(I - I_g)}$ $R = \frac{V}{I_g} - R_G$

- Elements of Earth's magnetic field

$H = B_E\cos\theta$ $V = B_E\sin\theta$

- P.E. of a magnetic dipole in a uniform magnetic field

$$U = -mB\cos\theta$$

- Magnetic dipole moment of a revolving electron

$$m = \frac{evr}{2} = n\left(\frac{eh}{4\pi m_e}\right)$$

- Magnetising field intensity

$$H = nI$$

- Intensity of magnetization

Important Formulae – EMI & AC

Physical Quantity	Formula	SI unit	Dimension
Magnetic flux (ϕ)	$\vec{B}\bullet\vec{A} = BA\cos\theta = \int \vec{B}\bullet d\vec{A}$	Wb = Tm^2	$[ML^2T^{-2}A^{-1}]$
Induced emf (ε)	$\varepsilon = -\frac{d\phi}{dt}$ Induced current $i = \frac{\varepsilon}{R} = -\frac{N}{R}\frac{d\phi}{dt}$ Induced charge $q = i\Delta t = -\frac{N}{R}\Delta\phi$ Motional emf induced in a straight conductor (i) Linear motion = Blv (ii) Rotation about one end = $Bl^2\omega/2$	Volt	$[ML^2T^{-1}A^{-1}]$
Self-inductance	$L = \phi/I$ and $L = \frac{\lvert\varepsilon\rvert}{dI/dt}$ Self-inductance of a long solenoid $L = \mu_r\mu_0 n^2 A\, l$	Henry	$[ML^2T^{-2}A^{-2}]$
Mutual inductance	$M_{12} = \phi_2/I_1$ and $M_{12} = \frac{\lvert\varepsilon_2\rvert}{dI_1/dt}$ Mutual-inductance of two long co-axial solenoids $M_{12} = \mu_0 n_1 n_2 \pi r^2 l$, $M_{12} = \surd^{3}L_1L_2{}'$	Henry	$[ML^2T^{-2}A^{-2}]$
Magnetostatic energy stored	$U = \frac{1}{2} LI^2$	Joule	$[ML^2T^{-2}]$
Alternating current and voltage	$\varepsilon = \varepsilon_0 \sin(\omega t+\phi)$ or $\varepsilon = \varepsilon_0 \cos(\omega t+\phi)$ $i = I_0 \sin(\omega t+\phi)$ or $i = I_0 \cos(\omega t+\phi)$ $I_{rms} = \frac{I_o}{\sqrt{2}} = 0.707\, I_0$ and $\varepsilon_{rms} = \frac{\varepsilon_o}{\sqrt{2}} = 0.707\, \varepsilon_0$		
Phase relationship	**For R** : No phase difference bet^n V and I **For L**: Voltage leads the current by π/2 **For C**: Current leads the voltage by π/2 **For LCR circuit: if f > f_r** $\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right)$ or $\phi = \tan^{-1}\left(\frac{V_L - V_C}{V_R}\right)$ **If f<f_r** $\phi = \tan^{-1}\left(\frac{X_C - X_L}{R}\right)$ or $\phi = \tan^{-1}\left(\frac{V_C - V_L}{V_R}\right)$	Unitless	Dimensionless
Reactance and impedance	Inductive reactance $X_L = \omega L$ Capacitive reactance $X_C = 1/\omega C$ Impedance of LR circuit $Z = \sqrt{\{X_L^2 + R^2\}}$ Impedance of RC circuit $Z = \sqrt{\{X_C^2 + R^2\}}$ Impedance of LCR circuit $Z = \sqrt{\{(X_L - X_C)^2 + R^2\}}$	Ohm	$[ML^2T^{-1}A^{-2}]$
Resonance frequency	$f_r = \frac{1}{2\pi\sqrt{LC}}$, angular frequency $\omega_r = \frac{1}{\sqrt{LC}}$	Hertz, rad/s	$[T^{-1}]$
Quality factor	$Q = \frac{1}{R}\sqrt{\frac{L}{C}} = \frac{\omega_r}{2\Delta\omega} = \frac{\omega_r L}{R} = \frac{1}{\omega_r CR}$	Unit less	Dimensionless

Power dissipated in ac circuit	In pure inductor and capacitor: Zero In pure resistive circuit: $I^2R/2$ In a combination of L,C and R: $V_{rms}I_{rms}\cos\phi$	Watt	$[ML^2T^{-3}]$
Power factor	$\cos\phi = R/Z$	Unit less	Dimensionless
Wattles current	$I_{rms}\cos\phi$	Ampere	[A]
Transformation ratio and efficiency of transformer	$\frac{v_S}{v_P} = \frac{N_S}{N_P}$ Efficiency:- $\eta = \frac{v_s I_s}{v_p I_p} = \frac{P_0}{P_i}$	Unit less	Dimensionless

IMPORTANT FORMULAE- ELECTROMAGNETIC WAVES

1. **Concept of displacement current**

   Displacement current is that current which appears in a region in which the electric field (and hence electric flux) is changing with time.

   Note- We have $I_D = \varepsilon_0 \frac{d\phi_E}{dt} = \varepsilon_0 \frac{d}{dt}(EA) = = \varepsilon_0 \frac{d}{dt}(\frac{q}{\varepsilon_{0A}} A) = = \frac{dq}{dt} = I$

2. **Modified Ampere's circuital Law**

   $\oint B.dl = \mu_0 (I + \varepsilon_0 \frac{d\phi_E}{dt})$

3. **Mathematical expression of EM-waves**

   $E_y = E_0 \sin 2\pi(\frac{x}{\lambda} - \frac{t}{T})\hat{j}$

$B_Z = B_0 \sin 2\pi(\frac{x}{\lambda} - \frac{t}{T})\hat{k}$

*Velocity of em waves in a free space $v = c = \frac{1}{\sqrt{\mu_0\varepsilon_0}} = 3 \times 10^8$ m/s

* Velocity of em waves in a medium is given by $v = \frac{c}{\sqrt{\mu_r K}}$

*E.M. waves are transverse in nature i,e, E & B are perpendicular to each other as well as perpendicular to the direction of propagation of the wave. E & B are related as follows -

$\frac{E_0}{B_0} = c$ or $\frac{E}{B} = c$

IMPORTANT FORMULAE- OPTICS

- Relation between focal length and radius of curvature of a mirror/lens, f = R/2
- Mirror formula: $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$
- Magnification produced by a mirror: m = $-\frac{v}{u} = -\frac{f}{u-f}$
- Snell's law: $\frac{\sin i}{\sin r} = {}^1n_2 = \frac{n_2}{n_1}$
- ${}^2n_1 = \frac{1}{{}^1n_2}$
- n = $\frac{c}{v} = \frac{\text{speed of light in vacuum}}{\text{speed of light in a medium}} = \frac{\lambda_{air}}{\lambda_{medium}}$
- If object is in medium of refractive index n, then n = $\frac{\text{real depth}}{\text{apparent depth}} = \frac{t}{t_{app}}$
- Critical angle for total internal reflection: sin C = $\frac{1}{{}^rn_d} = \frac{1}{n}$
- Refraction at spherical (convex) surface: For object in rarer medium and real image in denser medium, the formula is $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$ where n_2 & n_1 are the refractive indices of denser and rarer media.
- Lens formula: $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$
- Linear magnification produced by a lens: m = $\frac{I}{O} = \frac{v}{u}$
- Lens maker's formula : $\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = ({}^an_g - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] = (n-1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$
- Power of a lens: P = $\frac{1}{f}$ diopter (f is in metre)
- Lenses in contact: $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$ or P = $P_1 + P_2$
- Focal length of lens in liquid: $f_l = \frac{n_g - 1}{\frac{n_g}{n_l} - 1} \times f_a$
- Refraction through a prism: $r_1 + r_2 = A$ and $i + e = A + \delta$ where A is angle of prism and δ is angle of deviation.
- For minimum deviation, i = e = i and $r_1 + r_2 = r$. Therefore, $\delta_m = 2i - A$
- Refractive Index of the material of prism: $n = \frac{\sin i}{\sin r} = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$
- For a thin prism: $\delta = (n-1)A$
- Simple microscope: Magnifying power $M = 1 + \frac{D}{f}$ (if final image is at D)

  $= \frac{D}{f}$ (if final image is at infinity)
- Compound microscope:
  - i) Magnification M = $m_o m_e$
  - ii) Magnification M = $-\frac{v_o}{u_o}\left\{1 + \frac{D}{f_e}\right\} \approx -\frac{L}{f_o}\left\{1 + \frac{D}{f_e}\right\}$ (for final image at D)
  - ii) Magnification M = $-\frac{v_o}{u_o}\left\{\frac{D}{f_e}\right\} \approx -\frac{L}{f_o}\left\{\frac{D}{f_e}\right\}$ (for final image at infinity)
- Astronomical Telescope:
  - i) M = $-\frac{f_o}{f_e}$ and L= $f_o + f_e$ (for final image at infinity)
  - ii) M = $-\frac{f_o}{f_e}\left\{1 + \frac{f_e}{D}\right\}$ and L= $f_o + u_e$ (for final image at D)
- Resolving power:
  - i) **For microscope**: - The resolving power is the reciprocal of limit of resolution or separation between two points such that they are distinct. So, the resolving power is given by R.P.= $\frac{1}{d} = \frac{2\,n\,sin\theta}{\lambda}$

Here, $d = \frac{\lambda}{2\, n\, sin\theta}$ is limit of resolution, $n\, sin\theta$ is numerical aperture and θ is the well resolved semi-angle of cone of light rays of wavelength λ entering the microscope.

i) **For telescope**: - The resolving power is the reciprocal of angular limit of resolution or angle subtended between two points such that they are distinct. So, the resolving power is given by R.P.= $\frac{1}{d\theta} = \frac{a}{1.22\,\lambda}$

Here, $d\theta = \frac{1.22\,\lambda}{a}$ is the angular limit of resolution, 'a' is the aperture or diameter of objective lens.

- Interference of light:-

i) If two waves of same intensity I_o interfere, then the resultant intensity will be $I = 4\, I_o \cos^2\frac{\phi}{2}$ where ϕ is the initial phase difference between the waves.

ii) Resultant intensity at a point in the region of superposition is

$$I = a_1^2 + a_2^2 + 2a_1a_2\cos\phi = I_1 + I_2 + 2\sqrt{I_1\, I_2}\,\cos\phi \text{ where}$$

$I_1 = a_1^2$ is the intensity of one wave & $I_2 = a_2^2$ is the intensity of other wave.

iii) Condition for maxima: - Phase difference ϕ = 2nπ & path difference Δ= n λ where n = 0,1,2,3,…..

iv) Condition for minima: - Phase difference ϕ = (2n-1)π &

Path difference Δ= (2n-1) $\frac{\lambda}{2}$ where n = 0,1,2,3,…..

v) Fringe width $\beta = \frac{D\,\lambda}{d}$ where D = distance between the slits & the screen, d= separation between the slits and λ is the wavelength of light used.

vi) Angular fringe width , $\beta_\theta = \frac{\beta}{D} = \frac{\lambda}{d}$

vii) Minimum amplitude, $A_{min} = (a_1 - a_2)$

viii) Minimum intensity, $I_{min} = (a_1 - a_2)^2 = I_1 + I_2 - 2\sqrt{I_1\, I_2}$

ix) Position of n^{th} maxima, $y_n = \frac{nD\,\lambda}{d}$

x) Position of n^{th} minima, $y_n = (n - ½)\frac{D\,\lambda}{d}$

- Diffraction of light: -

i) The condition for the position of n^{th} minima : d sinθ = n λ where d is the width of slit, θ is angle of diffraction and λ is the wavelength of light used.

ii) Linear half-width of central maximum : $y = \frac{D\,\lambda}{d}$

iii) Total linear width of central maximum : β_o or $2y = \frac{2\,D\,\lambda}{d}$

In interference, the ratio of maximum intensity to minimum intensity, $\frac{I_{max}}{I_{min}} = \frac{(a_1+a_2)^2}{(a_1-a_2)^2}$

In interference, the relation between slit width (w) , intensity (I) and amplitude (a):

$$\frac{w_1}{w_2} = \frac{I_1}{I_2} = \frac{(a_1)^2}{(a_2)^2}$$

The angular width of each fringe in interference pattern, $\Delta\theta = \frac{\beta}{D} = \frac{\lambda}{d}$

IMPORTANT FORMULAE-DUAL NATURE OF RADIATION & MATTER

1. Energy of a photon $E = h\upsilon = \frac{hc}{\lambda}$
2. Number of photon emitted per second $N = \frac{P}{E}$
3. Momentum of photon $p = mc = \frac{h\upsilon}{c} = \frac{h}{\lambda} = \frac{E}{c}$
4. Equivalent mass of photon $m = \frac{h\upsilon}{c2} = \frac{E}{c2} = \frac{h}{c\lambda}$
5. Work function $W_0 = h\upsilon_0 = \frac{hc}{\lambda 0}$
6. Kinetic energy of photoelectron is given by Einstein's photoelectric equation:

   $$K_{max} = \frac{1}{2}mv^2 = h\upsilon - W_0 = h(\upsilon - \upsilon_0) = h\left(\frac{c}{\lambda} - \frac{c}{\lambda 0}\right)$$

7. If V_0 is the stopping potential, the maximum kinetic energy of the ejected photoelectron,

   $K = \frac{1}{2}mv^2_{max} = eV_0$
8. Kinetic energy of de-Broglie waves $K = \frac{1}{2}mv^2 = p^2/2m$
9. Momentum of de-Broglie waves $p = \sqrt{2mK}$
10. Wavelength of de-Broglie waves $\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\sqrt{(2mK)}}$
11. de –Broglie wavelength of an electron beam accelerated through a potential difference of V volts is

    $$\lambda = \frac{h}{\sqrt{(2meV)}} = \frac{1.23}{\sqrt{V}} \text{ nm} = \frac{12.27}{\sqrt{V}} A^o$$

12. de –Broglie wavelength associated with gas molecules of mass m at temperature T kelvin is

    $\lambda = \frac{h}{\sqrt{(2mKT)}}$ K = Boltzmann constant
13. The value of $hc = 12400 eV A^0$
14. The value of $\frac{hc}{e} = 1240 \times 10^{-9} eV\ m$
15. Bragg's equation for crystal diffraction is $2d\sin\theta = n\lambda$, n is the order of the spectrum

IMPORTANT FORMULAE – ATOMS & NUCLEI

1. Rutherford's α-Particle scattering experiment (Geiger – Marsden experiment)
   IMPORTANT OBSERVATION
   Scattering of α-particles by heavy nuclei is in accordance with coulomb's law. Rutherford observed that number of α-particles scattered is given by
   $$N \propto \frac{1}{\sin^4 \theta/2}$$
2. Distance of closest approach : Estimation of size of nucleus
   $$r_0 = \frac{1}{4\pi\varepsilon_0} \frac{Ze \, X \, 2e}{\frac{1}{2} m v^2}$$
3. Impact Parameter (b)
   $$b = \frac{Ze^2 \cot\theta/2}{4\pi\varepsilon_0 \left(\frac{1}{2} m u^2\right)}$$
4. Bohr's atomic model
   Radius of orbit $r = \frac{(4\pi\varepsilon_0) n^2 h^2}{4\pi^2 m Ze^2}$ Frequency $\nu = \frac{2\pi Ze^2}{(4\pi\varepsilon_0) n h}$
   $v = \frac{2\pi Ze^2}{(4\pi\varepsilon_0) c h} X \frac{c}{n} = \alpha \frac{c}{n}$ where $\alpha = \frac{2\pi Ze^2}{(4\pi\varepsilon_0) c h} = \frac{1}{137}$ is called fine structure constant

5. Energy of electron
   $E_n = -\frac{m Z^2 e^4}{8\varepsilon_0^2 h^2}\left(\frac{1}{n^2}\right)$ $E_n = -\frac{Z^2 Rch}{n^2}$ $R = \frac{m e^4}{8\varepsilon_0^2 ch^3} = 1.097 \times 10^7 \, m^{-1}$ and is called Rydberg constant.
   $E_n = -\frac{13.6}{n^2}$ eV $\bar{\nu} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ where $\bar{\nu}$ is called wave number.
   Short Cut Formula –

   K.E. = - (Total Energy)
   P.E. = - 2 K.E.

6. Bohr's quantisation condition for angular momentum
   $$mvr = n\frac{h}{2\pi}$$

7. Mass Defect (Δm) $\Delta m = [Z m_p + (A – Z) m_n] - m_N$
8. B.E. = $[\{Z m_p + (A – Z) m_n\} - m_N] \, c^2$
9. B.E. per nucleon = (B.E.)/A = $[\{Z m_p + (A – Z) m_n\} - m_N] \, c^2 / A$
10. B.E. = $[\{Z m_p + (A – Z) m_n\} - m_N]$x 931 MeV (if the masses are given in amu)

IMPORTANT FORMULAE- ELECTRONIC DEVICES

- Pure semiconductors are called intrinsic semiconductors, $n_e = n_h$ i.e. no. of electrons is equal to no. of holes.
- $n_e n_h = n_i^2$
- In n-type semiconductors $n_e >> n_h$ while in p-type semiconductors $n_h >> n_e$.
- For insulators $E_g > 3$ eV
- For semiconductors E_g is 0.2eV to 3 eV.
- For Germanium the forbidden energy gap is 0.7eV while it is 1.1eV in silicon.

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