HIGHLY RECOMMENDED

FOR 2021 & 2022 EXAMS

OSWAAL BOOKS®

LEARNING MADE SIMPLE

CBSE MCQs CHAPTERWISE QUESTION BANK FOR TERM I & II CLASS 12 PHYSICS

Strictly as per the Latest CBSE Circular No. Acad-53/2021 | Dated July 22, 2021

ACADEMICS' CHOICE SMART BOOK AWARD WINNER

MOST TRUSTED BRANDS OF INDIA 2021

THE ECONOMIC TIMES ICONIC BRANDS OF INDIA Made In India

Stand Alone MCQs

Case Based MCQs

Assertion & Reason

HIGHLY RECOMMENDED

FOR 2021 & 2022 EXAMS

OSWAAL BOOKS®

LEARNING MADE SIMPLE

CBSE MCQs CHAPTERWISE QUESTION BANK FOR TERM I & II CLASS 12

PHYSICS

Strictly as per the Latest CBSE Circular No. Acad-53/2021 | Dated July 22, 2021

ACADEMICS' CHOICE SMART BOOK AWARD WINNER

MOST TRUSTED BRANDS OF INDIA 2021

THE ECONOMIC TIMES ICONIC BRANDS OF INDIA Made In India

Stand Alone MCQs

Case Based MCQs

Assertion & Reason

Based on Termwise Syllabus 2021-22

1st EDITION **YEAR 2021-22**

ISBN "978-93-5463-566-3"

SYLLABUS COVERED

CENTRAL BOARD OF SECONDARY EDUCATION DELHI

PUBLISHED BY

OSWAAL BOOKS & LEARNING PVT. LTD.

1/11, Sahitya Kunj, M.G. Road,
Agra - 282002, (UP) India

1/1, Cambourne Business Centre
Cambridge, Cambridgeshire
CB 236DP, United kingdom

0562-2857671
0562-2527781

contact@oswaalbooks.com

www.OswaalBooks.com

DISCLAIMER

Oswaal Books has exercised due care and caution in collecting all the data before publishing this book.
In spite of this, if any omission, inaccuracy or printing error occurs with regard to the data contained in this book, Oswaal Books will not be held responsible or liable.
Oswaal Books will be grateful if you could point out any such error or offer your suggestions which will be of great help for other readers.

Printed at Parshwanath Printers, Agra

TABLE OF CONTENTS

❑❑

Get Unlimited Access to Free Resources

at: oswaalbooks.com/free-resources/

How? It's Easy as

Step 1: Visit oswaalbooks.com/ free-resources/ and choose your board and class.

Step 2: Not Registered? Register here quickly for the ocean of knowledge inside. (If registered already, simply login and move ahead)

Step 3: You are here! Enjoy this unlimited treat of FREE resources.

PREPARING FOR THE CHANGE

"Progress is impossible without change, and those who cannot change their minds cannot change anything." – **George Bernard Shaw.**

A lot has changed in the last couple of years. We have had to accept new ways of not just learning but also of living. To ensure that progress doesn't stop, online classes and remote learning gained prominence. These were unprecedented changes for most schools, yet we adapted to them pretty quickly. The main reason for it was that we want to move ahead; we don't want to be tied down by limitations and problems. Finding newer and better ways is vital for human progress.

The Special Scheme of Assessment recently introduced by the Central Board of Secondary Education (CBSE) is a fresh approach to ensure that the growth of students doesn't stop, even in the testing circumstances. It has ample flexibility and various assessment criteria to make up for a just evaluation system. Unlike previous years, the academic year will be divided into two terms. The first term will have only Multiple-Choice Questions of three types; Case-based, Assertion-Reason Types & Stand-alone MCQs. Unlike the traditional 3-hour paper, this will be a 90-minute test based on the 50% of the rationalized syllabus. The Second Term will be of 2-hour duration & have questions of different formats like Case-based/ Situation based, Open-ended, Short answer/Long answer type.

This is an excellent example of positivity, ensuring that students don't get stressed and focus on learning specific areas instead of cramming loads of information. This scheme will also boost the attempts of our education system to move from 'quantity' to 'quality.'

Also, with this scheme, students will be well prepared for Multiple Choice Questions, which are the most widely applicable & helpful type of test items like in NEET, JEE, CAT, CLAT, etc. These MCQ-type questions in the test will help the educators, parents & the students measure the most critical learning outcomes like knowledge, judgment, understanding of concepts & problem-solving.

How to prepare for the MCQs introduced in the Special Assessment Scheme?

Oswaal CBSE MCQs Chapter-wise Question Banks (For Term I & II) are based on the "Special Assessment Scheme" introduced by the board on 5th July 2021 and also on the rationalised Termwise syllabus released on 22nd July 2021.

These Question Banks include:

- Multiple Choice Questions based on the latest Typologies introduced by the board like:
  1. Stand- Alone MCQs,
  2. MCQs based on Assertion-Reason
  3. Case-based MCQs
- Questions from CBSE official Question Bank released in April 2021
- Competency based Questions-Understanding, Knowledge, Application, Evaluation and Creation.
- Answers with Explanations

Oswaal CBSE MCQs Chapter-wise Question Banks (For Term I & II) are specially curated by the Oswaal Editorial Board to help the student master the Multiple-Choice Questions.

Wish you all Happy Learning and a Successful 2021-22!!

केन्द्रीय माध्यमिक शिक्षा बोर्ड
CENTRAL BOARD OF SECONDARY EDUCATION

NO.: F.1001/CBSE-Acad/Curriculum/2021 **Date: July 22, 2021**

Circular No: Acad- 53/2021

All the Heads of Schools affiliated to CBSE

Subject: Term wise syllabus for Board Examinations to be held in the academic session 2021-22 for Secondary and Senior Secondary classes and guidelines for the conduct of the Internal Assessment/Practicum/Project.

This is in continuation to Board's circular number Acad 51/2021 dated July 05, 2021 regarding Special Scheme of Assessment for Board Examination for Classes X and XII for the Session 2021- 22. The syllabus for the two terms mentioned in the scheme in all subjects for classes IX to XII are hereby notified vides this circular. In addition to syllabus for term end board examinations, guidelines for the conduct of Internal Assessment/Practicum/Project are also enclosed.

Schools are requested to share the term wise syllabus and guidelines for the conduct of board examinations and Internal Assessment / Practicum / Project available on CBSE Academic Website **http://www.cbseacademic.nic.in** at the link **http://cbseacademic.nic.in/Term-wise-curriculum_2022.html** with all their teachers and students.

(Dr. Joseph Emmanuel)
Director (Academics)

CBSE CIRCULAR 2021-22

केन्द्रीय माध्यमिक शिक्षा बोर्ड
CENTRAL BOARD OF SECONDARY EDUCATION

CBSE/DIR (ACAD)/2021 **Date: July 05, 2021**

Circular No: A cad-51/2021

All the Heads of Schools affiliated to CBSE

Subject: Special Scheme of Assessment for Board Examination Classes X and XII for the Session 2021-22

COVID 19 pandemic caused almost all CBSE schools to function in a virtual mode for most part of the academic session of 2020-21. Due to the extreme risk associated with the conduct of Board examinations during the second wave in April 2021, CBSE had to cancel both its class X and XII Board examinations of the year 2021 and results are to be declared on the basis of a credible, reliable, flexible and valid alternative assessment policy. This, in turn, also necessitated deliberations over alternative ways to look at the learning objectives as well as the conduct of the Board Examinations for the academic session 2021-22 in case the situation remains unfeasible.

CBSE has also held stakeholder consultations with Government schools as well as private independent schools from across the country, especially schools from the remote rural areas and a majority of them have requested for the rationalization of the syllabus, similar to last year in view of reduced time permitted for organizing online classes. The Board has also considered the concerns regarding differential availability of electronic gadgets, connectivity and effectiveness of online teaching and other socio-economic issues, specially with respect to students from economically weaker sections and those residing in far flung areas of the country. In a survey conducted by CBSE, it was revealed that the rationalized syllabus notified for the session 2020-21, was effective for schools in covering the syllabus and helped learners in achieving learning objectives in a less stressful manner.

In the above backdrop and in line with the Board's continued focus on assessing stipulated learning outcomes by making the examinations competencies and core concepts based, student-centric, transparent, technology-driven and having advance provision of alternatives for different future scenarios, the following schemes are introduced for the Academic Session for Class X and Class XII, 2021-22.

1. **Special Scheme for 2021-22**
   - **A. Academic Session to be divided into 2 Terms with approximately 50% syllabus in each term:**

     The syllabus for the Academic Session 2021-22 will be divided into 2 terms by following a systematic approach by looking into the interconnectivity of concepts and topics by the Subject Experts and the Board will conduct examinations at the end of each term on the basis of the bifurcated syllabus. This is done to increase the probability of having the Board conducting classes X and XII examinations at the end of the academic session.
   - **B. The syllabus for the Board examination 2021-22 will be rationalized,** similar to that of the last academic session to be notified in July 2021. For academic transactions, however, schools will

follow the curriculum and syllabus released by the Board vide Circular no. F. 1001/CBSE-Acad/ Curriculum/2021 dated 31 March, 2021. Schools will also use alternative academic calendar and inputs from the NCERT on transacting the curriculum.

C. **Efforts will be made to make Internal Assessment/ Practical/ Project work more credible and valid** as per the guidelines and Moderation Policy to be announced by the Board to ensure fair distribution of marks.

2. Details of Curriculum Transaction

- Schools will continue teaching in distance mode till the authorities permit in- person mode of teaching in schools.
- **Classes IX-X: Internal Assessment** (throughout the year-irrespective of Term I and II) would include the *3 periodic tests, student enrichment, portfolio and practical work/ speaking-listening activities/ project.*
- **Classes XI-XII:** Internal Assessment (throughout the year-irrespective of Term I and II) would include end of topic or unit tests/ exploratory activities/ practicals/ projects.
- Schools would create a student profile for all assessments undertaken over the year and retain the evidences in digital format.
- CBSE will facilitate schools to upload marks of Internal Assessment on the CBSE IT platform.
- Guidelines for Internal Assessment for all subjects will also be released along with the rationalized term wise divided syllabus for the session 2021-22. The Board would also provide additional resources like sample assessments, question banks, teacher training, etc., for more reliable and valid internal assessments.

3. Term I Examinations:

- At the end of the first term, the Board will organize **Term I Examination** in a flexible schedule to be conducted between November-December 2021 with a window period of 4-8 weeks for schools situated in different parts of country and abroad. Dates for conduct of examinations will be notified subsequently.
- The Question Paper will have Multiple Choice Questions (MCQs) including case-based MCQs and MCQs on assertion-reasoning type. Duration of test will be **90 minutes** and it will cover the rationalized syllabus of **Term I only** (i.e., approx. 50% of the entire syllabus).
- Question Papers will be sent by the CBSE to schools along with marking scheme.
- The exams will be conducted under the supervision of the External Center Superintendents and Observers appointed by CBSE.
- The responses of students will be captured on OMR sheets which, after scanning may be directly uploaded at CBSE portal or alternatively may be evaluated and marks obtained will be uploaded by the school on the very same day. The final direction in this regard will be conveyed to schools by the Examination Unit of the Board.
- Marks of the **Term I** Examination will contribute to the final overall score of students.

4. Term II Examination/ Year-end Examination:

- At the end of the second term, the Board would organize **Term II or Year-end Examination** based on the rationalized syllabus of Term II only (i.e., approximately 50% of the entire syllabus).
- This examination would be held around **March-April 2022** at the examination centres fixed by the Board.

- The paper will be of **2 hours duration** and have questions of different formats (case-based/ situation based, open ended- short answer/ long answer type).
- In case the situation is not conducive for normal descriptive examination, a **90 minute MCQs** based exam will be conducted at the end of the Term II also.
- Marks of the Term II Examination would contribute to the final overall score.

5. Assessment / Examination as per different situations

A. In case the situation of the pandemic improves and students are able to come to schools or centres for taking the exams.

Board would conduct Term I and Term II examinations at schools/centres and the theory marks will be distributed equally between the two exams.

B. In case the situation of the pandemic forces complete closure of schools during November-December 2021, but Term II exams are held at schools or centres.

Term I MCQ based examination would be done by students online/offline from home - in this case, the weightage of this exam for the final score would be reduced, and weightage of Term II exams will be increased for declaration of final result.

C. In case the situation of the pandemic forces complete closure of schools during March-April 2022, but Term I exams are held at schools or centres.

Results would be based on the performance of students in Term I MCQ based examination and internal assessments. The weightage of marks of Term I examination conducted by the Board will be increased to provide year end results of candidates.

D. In case the situation of the pandemic forces complete closure of schools and Board conducted Term I and II exams are taken by the candidates from home in the session 2021-22.

Results would be computed on the basis of the Internal Assessment/ Practical/ Project Work and Theory marks of Term-I and II exams taken by the candidate from home in Class X / XII, subject to the moderation or other measures to ensure validity and reliability of the assessment.

In all the above cases, data analysis of marks of students will be undertaken to ensure the integrity of internal assessments and home based exams.

(Dr. Joseph Emmanuel)

Director (Academics)

SYLLABUS

PHYSICS (Code No. 042)
CLASS–XII (THEORY)
2021-22

Physics Theory and Practical course will be done in two terms. Each term will be assessed individually.
Syllabus assigned for Term I (Theory)

Time : 90 Minutes **Max Marks: 35**

		No. of Periods	Marks
Unit I	**Electrostatics**	23	17
	Chapter–1: Electric Charges and Fields		
	Chapter–2: Electrostatic Potential and Capacitance		
Unit II	**Current Electricity**	15	
	Chapter–3: Current Electricity		
Unit III	**Magnetic Effects of Current and Magnetism**	16	18
	Chapter–4: Moving Charges and Magnetism		
	Chapter–5: Magnetism and Matter		
Unit IV	**Electromagnetic Induction and Alternating Currents**	19	
	Chapter–6: Electromagnetic Induction		
	Chapter–7: Alternating Current		
	Total	73	35

Unit I : Electrostatics **(23 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

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 polarisation, 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.

Unit II : Current Electricity **15 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, electrical resistance, 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 laws and simple applications, Wheatstone bridge, metre bridge **(qualitative ideas only)**. Potentiometer - principle and its applications to measure potential difference and for comparing EMF of two cells; measurement of internal resistance of a cell **(qualitative ideas only)**

SYLLABUS

Unit III : Magnetic Effects of Current and Magnetism **16 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 and toroidal solenoids (only qualitative treatment), force on a moving charge in uniform magnetic and electric fields. Force on a current-carrying conductor in a uniform magnetic field, force between two parallel current-carrying conductors-definition of ampere, torque experienced by a current loop in uniform magnetic field; moving coil galvanometer-its current sensitivity and conversion to ammeter and voltmeter.

Chapter–5 : Magnetism and Matter

Current loop as a magnetic dipole and its magnetic dipole moment, magnetic dipole moment of a revolving electron, bar magnet as an equivalent solenoid, magnetic field lines; earth's magnetic field and magnetic elements.

Unit IV : Electromagnetic Induction and Alternating Currents **19 Periods**

Chapter–6 : Electromagnetic Induction

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

Chapter–7 : Alternating Current

Alternating currents, peak and RMS value of alternating current/voltage; reactance and impedance; LC oscillations (qualitative treatment only), LCR series circuit, resonance; power in AC circuits. AC generator and transformer.

Syllabus assigned for Practical for Term I

Total Periods:16

First term practical examination will be organised by schools as per the directions of CBSE The record to be submitted by the students at the time of first term examination has to include a record of at least 4 Experiments and 3 Activities to be demonstrated by teacher.

Evaluation Scheme

Time Allowed: one and half hours **Max. Marks: 15**

Two experiments to be performed by students at time of examination	**8 Marks**
Practical record [experiments and activities]	**2 Marks**
Viva on experiments, and activities	**5 Marks**
Total	**15 Marks**

Experiments assigned for Term I

1. To determine resistivity of two / three wires by plotting a graph between potential difference versus current.
2. To find resistance of a given wire / standard resistor using metre bridge.

   OR

   To verify the laws of combination (series) of resistances using a metre bridge.

   OR

   To verify the laws of combination (parallel) of resistances using a metre bridge.
3. To compare the EMF of two given primary cells using potentiometer.

   OR

   To determine the internal resistance of given primary cell using potentiometer.
4. To determine resistance of a galvanometer by half-deflection method and to find its figure of merit.
5. To convert the given galvanometer (of known resistance and figure of merit) into a voltmeter of desired range and to verify the same.

   OR

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

6. To find the frequency of AC mains with a sonometer.

Activities assigned for Term I

1. To measure the resistance and impedance of an inductor with or without iron core.
2. To measure resistance, voltage (AC/DC), current (AC) and check continuity of a given circuit using multimeter.
3. To assemble a household circuit comprising three bulbs, three (on/off) switches, a fuse and a power source.
4. To assemble the components of a given electrical circuit.
5. To study the variation in potential drop with length of a wire for a steady current.
6. To draw the diagram of a given open circuit comprising at least a battery, resistor/rheostat, key,

Syllabus assigned for Term II (Theory)

Course structure

Time : 2 Hours **Max Marks: 35**

Unit V	**Electromagnetic waves**	02	17
	Chapter–8: Electromagnetic waves		
Unit VI	**Optics**	18	
	Chapter–9: Ray Optics and Optical Instruments		
	Chapter–10: Wave Optics		
Unit VII	**Dual Nature of Radiation and Matter**	07	11
	Chapter–11: Dual Nature of Radiation and Matter		
Unit VIII	**Atoms and Nuclei**	11	
	Chapter–12: Atoms		
	Chapter–13: Nuclei		
Unit IX	**Electronic Devices**	07	7
	Chapter–14: Semiconductor -Electronics: Materials, Devices and Simple Circuits		
	Total	**45**	**35**

Unit V: Electromagnetic waves **2 Periods**

Chapter–8: Electromagnetic Waves

Electromagnetic waves, their characteristics, their Transverse nature (qualitative ideas only). Electromagnetic spectrum (radio waves, microwaves, infrared, visible, ultraviolet, X-rays, gamma rays) including elementary facts about their uses.

Unit VI: Optics **18 Periods**

Chapter–9: Ray Optics and Optical Instruments

Ray Optics: Refraction of light, total internal reflection and its applications, optical fibres, refraction at spherical surfaces, lenses, thin lens formula, lensmaker'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, coherent sources and sustained interference of light, diffraction due to a single slit, width of central maximum.

Unit VII: Dual Nature of Radiation and Matter **7 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 **11 Periods**

Chapter–12: Atoms

Alpha-particle scattering experiment; Rutherford's model of atom; Bohr model, energy levels, hydrogen spectrum.

Chapter–13: Nuclei

Composition and size of nucleus Nuclear force Mass-energy relation, mass

defect, nuclear fission, nuclear fusion.

Unit IX: Electronic Devices **7 Periods**

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

Energy bands in conductors, semiconductors and insulators (qualitative ideas only) Semiconductor diode - I-V characteristics in forward and reverse bias, diode as a rectifier; Special purpose p-n junction diodes: LED, photodiode, solar cell.

Syllabus assigned for Practical for Term II

Total Periods:16

The second term practical examination will be organised by schools as per the directions of CBSE and viva will be taken by both internal and external observers. The record to be submitted by the students at the time of second term examination has to include a record of at least 4 Experiments and 3 Activities to be demonstrated by teacher.

Evaluation Scheme

Time Allowed: one and half hours **Max. Marks: 15**

Two experiments to be performed by students at time of examination	**8 Marks**
Practical record [experiments and activities]	**2 Marks**
Viva on experiments, and activities	**5 Marks**
Total	**15 Marks**

Experiments assigned for Term-II

1. To find the focal length of a convex lens by plotting graphs between u and v or between 1/u and1/v.
2. To find the focal length of a convex mirror, using a convex lens.

   OR

   To find the focal length of a concave lens, using a convex lens.
3. To determine angle of minimum deviation for a given prism by plotting a graph between angle of incidence and angle of deviation.

4. To determine refractive index of a glass slab using a travelling microscope.
5. To find refractive index of a liquid by using convex lens and plane mirror.
6. To draw the I-V characteristic curve for a p-n junction diode in forward bias and reverse bias.

Activities assigned for Term-II

1. To identify a diode, an LED, a resistor and a capacitor from a mixed collection of such items.
2. Use of multimeter to see the unidirectional flow of current in case of a diode and an LED and check whether a given electronic component (e.g., diode) is in working order.
3. To study effect of intensity of light (by varying distance of the source) on an LDR.
4. To observe refraction and lateral deviation of a beam of light incident obliquely on a glass slab.
5. To observe polarization of light using two Polaroids.
6. To observe diffraction of light due to a thin slit.
7. To study the nature and size of the image formed by a (i) convex lens, (ii) concave mirror, on a screen by using a candle and a screen (for different distances of the candle from the lens/mirror).
8. To obtain a lens combination with the specified focal length by using two lenses from the given set of lenses.

Practical Examination for Visually Impaired Students of XII Evaluation Scheme (Term I and Term II)

Time Allowed: one hour **Max. Marks: 15**

Identification/Familiarity with the apparatus	**3 Marks**
Written test (based on given/prescribed practicals)	**5 Marks**
Practical Record	**2 Marks**
Viva	**5 Marks**
Total	**15 Marks**

General Guidelines

- The practical examination will be of one hour duration.
- A separate list of ten experiments is included here.
- The written examination in practicals for these students will be conducted at the time of practical examination of all other students.
- The written test will be of 10 minutes duration.
- The question paper given to the students should be legibly typed. It should contain a total of 8 practical skill based very short answer type questions. A student would be required to answer any 5 questions.
- A writer may be allowed to such students as per CBSE examination rules.
- All questions included in the question papers should be related to the listed practicals. Every question should require about two minutes to be answered.
- These students are also required to maintain a practical file. A student is expected to record at least five

of the listed experiments as per the specific instructions for each subject. These practicals should be duly checked and signed by the internal examiner.

- The format of writing any experiment in the practical file should include aim, apparatus required, simple theory, procedure, related practical skills, precautions etc.
- Questions may be generated jointly by the external/internal examiners and used for assessment.
- The viva questions may include questions based on basic theory/principle/concept, apparatus/ materials/ chemicals required, procedure, precautions, sources of error

Class XII

A. Items for Identification/ familiarity with the apparatus for assessment in practicals (All experiments)

Meter scale, general shape of the voltmeter/ammeter, battery/power supply, connecting wires, standard resistances, connecting wires, voltmeter/ammeter, meter bridge, screw gauge, jockey Galvanometer, Resistance Box, standard Resistance, connecting wires, Potentiometer, jockey, Galvanometer, Lechlanche cell, Daniell cell [simple distinction between the two vis-à-vis their outer (glass and copper) containers], rheostat connecting wires, Galvanometer, resistance box, Plug-in and tapping keys, connecting wires battery/power supply, Diode, Resistor (Wire-wound or carbon ones with two wires connected to two ends), capacitors (one or two types), Inductors, Simple electric/electronic bell, battery/power supply, Plug-in and tapping keys, Convex lens, concave lens, convex mirror, concave mirror, Core/hollow wooden cylinder, insulated wire, ferromagnetic rod, Transformer core, insulated wire.

Experiments assigned for Term-I

1. To determine the resistance per cm of a given wire by plotting a graph between voltage and current.
2. To verify the laws of combination (series/parallel combination) of resistances by Ohm's law.
3. To find the resistance of a given wire / standard resistor using a meterbridge.
4. To compare the e.m.f of two given primary cells using a potentiometer.
5. To determine the resistance of a galvanometer by half deflection method.

Experiments assigned for Term-II

1. To identify a resistor, capacitor, inductor and diode from a mixed collection of such items.
2. To observe the difference between
   (i) a convex lens and a concave lens
   (ii) a convex mirror and a concave mirror and to estimate the likely difference between the power of two given convex /concave lenses.
3. To design an inductor coil and to know the effect of
   (i) change in the number of turns
   (ii) Introduction of ferromagnetic material as its core material on the inductance of the coil.

4. To design a (i) step up (ii) step down transformer on a given core and know the relation between its input and output voltages.

Note: The above practicals may be carried out in an experiential manner rather than recording observations.

Prescribed Books:

1. Physics, Class XII, Part -I and II, Published by NCERT.
2. Laboratory Manual of Physics for class XII Published by NCERT.
3. The list of other related books and manuals brought out by NCERT (consider multimedia also).

❑❑

PART – I : ELECTROSTATICS

CHAPTER 1

Term-I

ELECTRIC CHARGES AND FIELDS

Syllabus

- *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*

STAND ALONE MCQs (1 Mark each)

Q. 1. Plastic rod rubbed with fur and glass rod rubbed with silk
(A) repel each other
(B) mix up with each other
(C) attract each other
(D) None of the above

Ans. Option (C) is correct.

> ***Explanation:*** Rubbing a rod with certain materials will cause the rod to become charged. A plastic rod when rubbed with fur becomes negatively charged and a glass rod when rubbed with silk becomes positively charged.

Q. 2. Electric charge between two bodies can be produced by
(A) sticking **(B)** rubbing
(C) oiling **(D)** passing AC current

Ans. Option (B) is correct.

> ***Explanation:*** The tribo-electric effect is a type of contact electrification on which certain materials become electrically charged after they come into frictional contact with a different material.

Q. 3. Electric charges under action of electric forces is called
(A) electrostatic **(B)** electric flux
(C) electric field **(D)** electric field lines

Ans. Option (A) is correct.

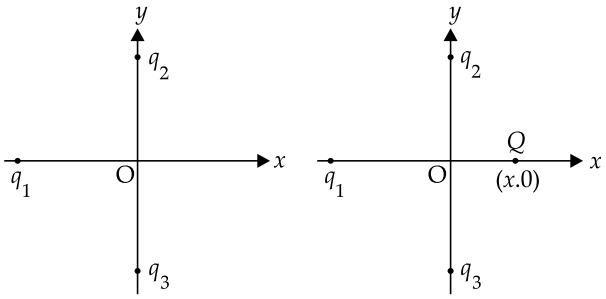
> ***Explanation:*** Coulomb force, also called electrostatic force or Coulomb interaction, attraction or repulsion of particles or objects because of their electric charge.

Q. 4. Law stating that "force is directly proportional to product of charges and inversely proportional to square of separation between them" is called
(A) Newton's law. **(B)** Coulomb's law
(C) Gauss's law. **(D)** Ohm's law

Ans. Option (B) is correct.

> ***Explanation:*** Coulomb's law states that : The magnitude of the electrostatic force of attraction or repulsion between two-point charges is directly proportional to the product of the magnitudes of charges and inversely proportional to the square of the distances between them.

Q. 5. In given figure, two positive charges q_2 and q_3 fixed along the y axis, exert a net electric force in the $+ x$ direction on a charge q_1 fixed along the x axis. If a positive charge Q is added at $(x, 0)$, the force on q_1



(A) shall increase along the positive x-axis.

(B) shall decrease along the positive x-axis.

(C) shall point along the negative x-axis.

(D) shall increase but the direction changes because of the intersection of Q with q_2 and q_3.

Ans. Option (A) is correct.

Explanation: Net force on charge q_1, by other charges q_2 and q_3 is along the + x-direction, so nature of force between q_1 and q_2 and q_1 and q_3 is attractive. This is possible when charge q_1 is negative. Now, if a positive charge Q is placed at $(x, 0)$, then, the force on q_1 will increase. The direction will be along positive x-axis.

Q. 6. The magnitude of electric force, F is

(A) directly proportional to the multiplication of both charges.

(B) directly proportional to the distance between both charges.

(C) directly proportional to the square of the distance between both charges.

(D) constant.

Ans. Option (A) is correct.

Explanation: The magnitude of the electric force F is directly proportional to the amount of an electric charge, q_1, multiplied by the other, q_2, and inversely proportional to the square of the distance 'r' between their centres.

Q. 7. A body is negatively charged means

(A) It has only negative charges.

(B) Positive charges have been neutralized by negative charges.

(C) The quantity of negative charge present is more than the quantity positive charge present.

(D) The positive are displaced from their original positions.

Ans. Option (C) is correct.

Explanation: When a neutral body gains electrons, it becomes negatively charged. It means that the quantity of negative charges present is more than the quantity of positive charge present.

Q. 8. When a body is charged by conduction, its mass

(A) remains same. **(B)** increases.

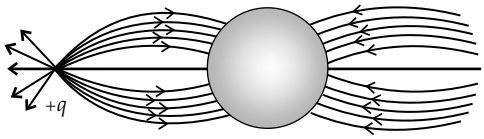
(C) decreases. **(D)** increase or decrease.

Ans. Option (D) is correct.

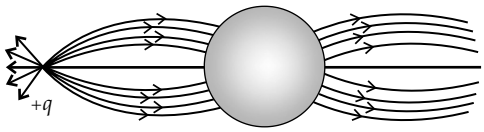
Explanation: When a body is negatively charged by conduction, it gains electrons. Hence, its mass increases. When a body is positively charged by conduction, it loses electrons. Hence, its mass decreases.

Q. 9. A point positive charge is brought near an isolated conducting sphere in Figure. The electric field is best given by :

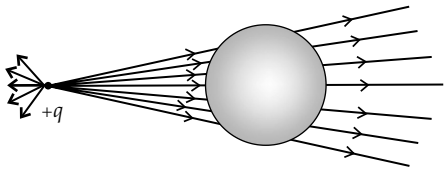
(i)



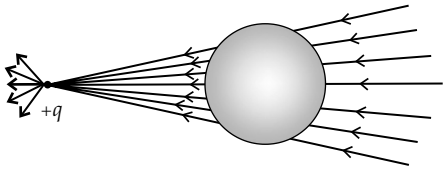
(ii)



(iii)



(iv)



(A) Fig (i) **(B)** Fig (iii)

(C) Fig (ii) **(D)** Fig (iv)

Ans. Option (B) is correct.

Explanation: As given charge is + q and lines of forces in positive charge must be outwards from positive charge q. Now, as the positive charge is kept near an isolated conducting sphere, due to induction, left part of sphere gets accumulated negative charge and right part gets positive, and lines of force from right part of sphere must emerge outwards normally.

So, verifies the answer (B)

As lines of forces are not perpendicular to the surface of sphere, so options (iii) and (iv) are not true again. Hence option (C) is not correct.

Q. 10. A point charge $+q$, is placed at a distance d from an isolated conducting plane. The field at a point P on the other side of the plane is

(A) directed perpendicular to the plane and away from the plane.

(B) directed perpendicular to the plane but towards the plane.

(C) directed radially away from the point charge.

(D) directed radially towards the point charge.

Ans. Option (A) is correct.

Explanation: When you place a positive charge near a conducting plane, then electric field lines from positive charges will enter into the conducting plane (from the side where positive charge is kept) and emerge from opposite side of the plane.
In both cases, the direction of electric field lines will always be perpendicular to the surface of the plane.

Q. 11. A hemisphere is uniformly charged positively. The electric field at a point on a diameter away from the centre is directed

(A) perpendicular to the diameter.

(B) parallel to the diameter.

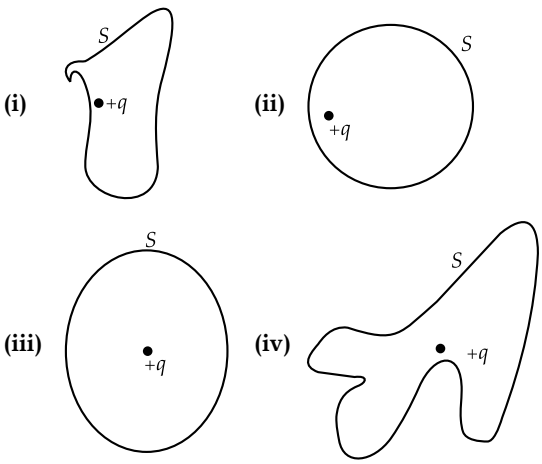
(C) at an angle tilted towards the diameter.

(D) at an angle tilted away from the diameter.

Ans. Option (A) is correct.

Explanation: As the side or diameter of hemisphere is plane surface, and whole hemisphere is charged with positive charge so, the electric field line of forces emerging outward will be perpendicular to the plane surface or diameter.

Q. 12. The electric flux through the surface :



(A) in Figure (iv) is the largest.

(B) in Figure (iii) is the least.

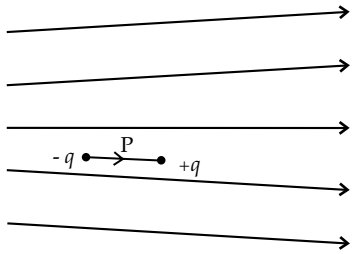
(C) in Figure (ii) is same as Figure (iii) but is smaller than Figure (iv).

(D) is the same for all the figures.

Ans. Option (D) is correct.

Explanation: Electric flux, through the closed surface (or space) depends only on the charge enclosed inside the surface. Here, charges inside all figures are same. So, electric flux will remain same.

Q. 13. Figure shows electric field lines in which an electric dipole p is placed as shown. Which of the following statements is correct?



(A) The dipole will not experience any force.

(B) The dipole will experience a force towards right.

(C) The dipole will experience a force towards left.

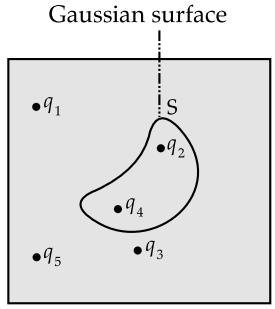
(D) The dipole will experience a force upwards.

Ans. Option (C) is correct.

Explanation: We know electric field emerges radially outward from positive point charge.
In the figure given above, space between field lines is increasing (or density of electric field line is decreasing). In other words, the electric force is decreasing while moving from left to right.
Thus, the force on charge $-q$ is greater than the force on charge $+q$ and in turn, dipole will experience a force towards left direction.

Q .14. Five charges q_1, q_2, q_3, q_4, and q_5 are fixed at their positions as shown in Figure. S is a Gaussian surface. The Gauss's law is given by:

$$\oint E.ds = q/\varepsilon_0$$



Which of the following statements is correct?

(A) E on the LHS of the above equation will have a contribution from q_1, q_5 and q_3, while q on the RHS will have a contribution from q_2 and q_4 only.

(B) E on the LHS of the above equation will have a contribution from all charges, while q on the RHS will have a contribution from q_2 and q_4 only.

(C) E on the LHS of the above equation will have a contribution from all charges, while q on the RHS will have a contribution from q_1, q_3 and q_5 only.

(D) Both E on the LHS and q on the RHS will have contributions from q_2 and q_4 only.

Ans. Option (B) is correct.

Explanation: As all charges are positive (or of same signs), so electric field lines on R.H.S. of Gaussian surface will be due to q_2 and q_4 only.
On L.H.S. of Gaussian surface, the electric field lines on 'E' will be due to q_1, q_2, q_3, q_4 and q_5. So, answer (B) is verified.

Q. 15. The Electric field at a point is

(A) always discontinuous.

(B) discontinuous if there is a positive charge at that point.

(C) discontinuous only if there is a negative charge at that point.

(D) discontinuous if there is a charge at that point.

Ans. Option (D) is correct.

Explanation: Either positive or negative charge will interact with the lines of electric field, so the electric field will become discontinuous.

Q. 16. If there is only one type of charge in the universe, then

(A) $\oint E.ds \neq 0$ on any surface.

(B) $\oint E.ds = \varepsilon_0/q$ if the charge is outside the surface.

(C) $\oint E.ds$ cannot not be defined.

(D) $\oint E.ds = q/\varepsilon_0$ if charges of magnitude q is inside the surface.

Ans. Option (D) is correct.

Explanation: If a charge q is enclosed inside Gaussian surface then according to Gauss law $\oint E.ds = q/\varepsilon_0$.

ASSERTION AND REASON BASED MCQs (1 Mark each)

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

Q. 1. Assertion (A): In a non-uniform electric field, a dipole will have translatory as well as rotatory motion.

Reason (R): In a non-uniform electric field, a dipole experiences a force as well as torque.

Ans. Option (A) is correct.

Explanation: When an electric dipole is placed in a uniform electric field at an angle θ with the field, the dipole experiences a torque.
The torque produced by two parallel forces qE acting as couple = τ

$$\tau = q\text{E}\ (2l \sin\theta)$$

In case of non-uniform field, force acting on both the ends of the dipole will not be equal. So, there will be a combination of couple and a net force. In this way, dipole will have both rotational as well as linear motion.
So, both assertion and reason are true. Reason also explains the assertion.

Q. 2. Assertion (A): The basic difference between magnetic lines of force and electric lines of force is electric lines of force are discontinuous and magnetic lines of force are continuous.

Reason (R): Magnetic lines of force exist in a magnet but no electric lines of force exists in a charged body.

Ans. Option (A) is correct.

Explanation: Let us consider an electric dipole. The electric lines of force exists outside only and not inside the dipole.
Let us now consider a magnetic dipole. The magnetic lines of force exist outside as well as inside the dipole.
So, it can be said that magnetic lines of force are continuous and electric lines of force are discontinuous.
So assertion and reason both are true and reason explains the assertion too.

Q. 3. Assertion (A): Electric lines of force cross each other.

Reason (R): The resultant electric field at a point is the superimposition of the electric fields at that point.

Ans. Option (D) is correct.

Explanation: Electric lines of force never cross each other. If they cross each other, then at that point, we get two directions of electric field at that point, which is not possible. So, the assertion is false. The resultant electric field at a point is a vector sum of the electric fields at that point.

Q. 4. Assertion (A): When bodies are charged through friction, there is transfer of charge from one body to another. No charge is created or destroyed.

Reason (R): This is according to the law of conservation of electric charge.

Ans. Option (A) is correct.

Explanation: When two bodies are rubbed, electrons move from one body to another. The body which loses electrons becomes positively charged. The body which receives the electron becomes negatively charged. So, the assertion is true.

Law of conservation of electric charge states that electric charge can neither be created nor destroyed. In a closed system, the amount of charge remains same. Hence the reason is also true and properly explains the assertion.

Q. 5. Assertion (A): If two spherical conductors of different radii have the same surface charge densities, then their electric field intensities will be equal.

Reason (R): Surface charge density = $\frac{\text{Total charge}}{\text{area}}$

Ans. Option (B) is correct.

Explanation: If σ be the surface charge density of the two spheres of radius r and R, then electric fields for the two spheres are respectively:

$$E_1 = \frac{\kappa 4\pi r^2 \sigma}{r^2} = \kappa 4\pi\sigma$$

$$E_2 = \frac{\kappa 4\pi R^2 \sigma}{R^2} = \kappa 4\pi\sigma$$

So electric field intensities are equal. The assertion is true.

Surface charged density is charge per unit area = Total charge/area.

So reason is also true.

But the reason does not explain the assertion.

Q. 6. Assertion (A): In a cavity in a conductor, the electric field is zero.

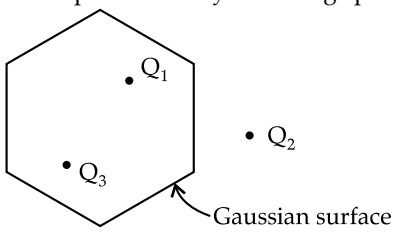
Reason (R): Charges in a conductor reside only at its surface.

Ans. Option (A) is correct.

Explanation: The charge enclosed by the Gaussian surface surrounding the cavity is zero. Hence, the electric field is also zero. So, the assertion is true.

Charges in a conductor reside only at its surface. So, in cavity there is no charge. So, the reason is also true and properly explains the assertion.

Q. 7. Assertion (A): Three point charges Q_1, Q_2 and Q_3 are shown in the figure. The flux over the Gaussian surface depends on only one charge point.



Reason (R): Electric flux depends on the all charges nearby.

Ans. Option (D) is correct.

Explanation: According to Gauss's law, electric flux depends on the enclosed charges only. Here the enclosed charges are Q_1 and Q_3 only. Hence the assertion is false and the reason is true.

Q. 8. Assertion (A): Using Gauss law, it is possible to find the electric field at any point.

Reason (R): Gauss law is applicable for any type of charge distribution.

Ans. Option (C) is correct.

Explanation: Considering suitable Gaussian surface, we can easily find the electric field at any point. So, the assertion is true.

But it is very very difficult to apply Gauss law, if the charge distribution is so that the Gaussian surface is complicated in shape. So, reason is false.

CASE-BASED MCQs

Attempt any 4 sub-parts out of 5. Each question carries 1 mark.

I. Read the following text and answer the following questions on the basis of the same:

Faraday Cage: A Faraday cage or Faraday shield is an enclosure made of conducting material. The fields within a conductor cancel out with any external fields, so the electric field within the encloser is zero. These Faraday cages act as big hollow conductors you can put things in to shield them from electrical fields. Any electrical shocks the cage receives, pass harmlessly around the outside of the cage.

Q. 1. Which of the following material can be used to make a Faraday cage ?

(A) Plastic **(B)** Glass

(C) Copper **(D)** Wood

Ans. Option (C) is correct.

Explanation: A Faraday cage or Faraday shield is an enclosure made of a conducting material. Since copper is the only metal given in the list of options, copper is the correct answer.

Q. 2. Example of a real-world Faraday cage is :

(A) car **(B)** plastic box

(C) lighting rod **(D)** metal rod

Ans. Option (A) is correct.

Explanation: Cars are example of Faraday Cages in the real world. Cars can help keep us safe from lightning. Its metal body acts as a Faraday Cage.

Q. 3. What is the electrical force inside a Faraday cage when it is struck by lightning ?

(A) The same as the lightning

(B) Half that of the lightning

(C) Zero

(D) A quarter of the lightning

Ans. Option (C) is correct.

Explanation: The field within a conductor cancel out with any external fields, so the electric field within the enclosure is zero.

Q. 4. If isolated point charge $+q$ is placed inside the Faraday cage. Its surface must have charge equal to :

(A) Zero **(B)** $+q$

(C) $-q$ **(D)** $+2q$

Ans. Option (C) is correct.

Explanation: If a charge is placed inside an ungrounded Faraday shield without touching the walls of the internal face of the shield becomes charged with $-q$, and $+q$ accumulates on the outer face of the shield. If the cage is grounded, the excess charges will be neutralized by the ground connection.

Q. 5. A point charge of 2 C is placed at centre of Faraday cage in the shape of cube with surface of 9 cm edge. The number of electric field lines passing through the cube normally will be :

(A) 1.9×10^5 Nm^2/C entering the surface.

(B) 1.9×10^5 Nm^2/C leaving the surface.

(C) 2.0×10^5 Nm^2/C leaving the surface.

(D) 2.0×10^5 Nm^2/C entering the surface.

Ans. Option (D) is correct.

Explanation: The number of electric field lines passing through the cube normally and leaving the surface = Q/ε_0

$$Q = 2\,\mu C = 2 \times 10^{-6}\ C$$

$$\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/Nm^2$$

$$\therefore \quad Q/\varepsilon_0 = 2.2 \times 10^5\ C^2/Nm^2$$

II. Read the following text and answer the following questions on the basis of the same:

Tribo-electric series:

The tribo-electric series is a list that ranks materials according to their tendency to gain or lose electrons. The process of electron transfer as a result of two objects coming into contact with one another and then separating is called tribo-electric charging. During such an interaction, one of the two objects will always gain electrons (becoming negatively charged) and the other object will lose electrons (becoming positively charged). The relative position of the two objects on the tribo-electric series will define which object gains electrons and which object loses electrons.

In tribo-electric series, materials are ranked from high to low in terms of the tendency for the material to lose electron. If an object high up on this list (Glass, for example) is rubbed with an object low down on the list (Teflon, for example), the glass will lose electrons to the teflon. The glass will, in this case, become positively charged and the teflon will become negatively charged. Materials in the middle of the list (steel and wood, for example) are items those do not have a strong tendency to give up or accept electrons.

Q. 1. Materials in the upper position has _____ tendency to become positively charged.

(A) low **(B)** high

(C) no **(D)** medium

Ans. Option (B) is correct.

Explanation: In tribo-electric series, materials are ranked from high to low in terms of the tendency for the material to lose electron i.e. they are ranked high to low tendency of getting positively charged.

Q. 2. Name two materials which do not have a strong tendency to give up or accept electrons.

(A) Ebonite, Nylon **(B)** Plastic wrap, Teflon

(C) Nylon, cat fur **(D)** Steel, wood

Ans. Option (D) is correct.

> ***Explanation:*** Materials in the middle of the list (steel and wood, for example) are items those do not have a strong tendency to give up or accept electrons.

Q. 3. If human hair is rubbed with amber, how those will be charged?

(A) Both negative

(B) Both positive

(C) Hair will be positively charged, Amber will be negatively charged.

(D) Hair will be negatively charged, Amber will be positively charged.

Ans. Option (D) is correct.

> ***Explanation:*** Since human hair is placed at the upper portion of the list, it will leave electron and will be positively charged. Since amber is placed at the lower portion of the list, it will accept the electron and will be negatively charged.

Q. 4. Tribo-electric charging is the process of electron transfer between two objects

(A) By contact

(B) Without contact

(C) By any one of the above

(D) By none of the above

Ans. Option (A) is correct.

> ***Explanation:*** The process of electron transfer as a result of two objects coming into contact with one another and then separating is called tribo-electric charging.

Q. 5. The object which loses electron becomes _____ charged and the object gains electron becomes _____ charged.

(A) negatively, negatively

(B) positively, positively

(C) positively, negatively

(D) negatively, positively

Ans. Option (C) is correct.

> ***Explanation:*** During tribo-electric charging, one of the two objects always gains electrons and become negatively charged. The other object loses electrons and become positively charged.

❐❐

CHAPTER 2

Term-I

ELECTROSTATIC POTENTIAL AND CAPACITANCE

Syllabus

- *Electric potential, potential difference, electric potential due to a point charge, electric 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 polarisation, 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.*

STAND ALONE MCQs (1 Mark each)

Q.1. The electrostatic potential on the surface of a charged conducting sphere is 100 V.

Two statements are made in this regard :

S_1 : At any point inside the sphere, electric intensity is zero.

S_2 : At any point inside the sphere, the electrostatic potential is 100 V.

Which of the following is a correct statement?

(A) S_1 is true, but S_2 is false.

(B) Both S_1 and S_2 are false.

(C) S_1 is true, S_2 is also true and S_1 is the cause of S_2.

(D) S_1 is true, S_2 is also true but the statements are independent.

Ans. Option (C) is correct.

Explanation: The relation between electric field intensity E and potential (V) is,

$$E = -\frac{dV}{dr}$$

Where, Electric field intensity, E = 0 inside the sphere

So that, $\frac{dV}{dr} = 0$

This means that V = constant. So, if E = 0 inside charged sphere, the potential is constant or V = 100 V everywhere inside the sphere and it verifies the shielding effect also. So, it verifies the option (C).

Q. 2. Equipotential at a great distance from a collection of charges whose total sum is not zero are approximately

(A) spheres. **(B)** planes.

(C) paraboloids. **(D)** ellipsoids.

Ans. Option (A) is correct.

Explanation: For equipotential surface, these surfaces are perpendicular to the field lines. So there must be electric field, which cannot be without charge.

So the algebraic sum of all charges must not be zero. Equipotential surface at a great distance means that space of charge is negligible as compared to distance. So the collection of charges is considered as a point charge.

Electric potential due to point charge is,

$$V = k_e \frac{q}{r}$$

which explains that electric potentials due to point charge is same for all equidistant points. The locus of these equidistant points, which are at same potential, forms spherical surface.

Q. 3. A positively charged particle is released from rest in an uniform electric field. The electric potential energy of the charge

(A) remains a constant because the electric field is uniform.

(B) increases because the charge moves along the electric field.

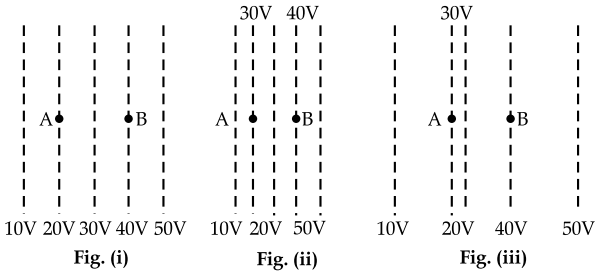
(C) decreases because the charge moves along the electric field.

(D) decreases because the charge moves opposite to the electric field.

Ans. Option (C) is correct.

> ***Explanation:*** As we know that, an equipotential surface is always perpendicular to the direction of electric field. Positive charge experiences the force in the direction of electric field. When a positive charge is released from rest in uniform electric field, its velocity increases in the direction of electric field. So K.E. increases, and the P.E. decreases due to law of conservation of energy.

Q. 4. Figure shows some equipotential lines distributed in space. A charged object is moved from point A to point B.



(A) The work done in Figure (i) is the greatest.

(B) The work done in Figure (ii) is least.

(C) The work done is the same in Figure (i), Figure (ii) and Figure (iii).

(D) The work done in Figure (iii) is greater than Figure (ii), but equal to that in Figure (i).

Ans. Option (C) is correct.

> ***Explanation:*** The work done by the electrostatic force is given by $W_{12} = q\,(V_2 - V_1)$
> As the potential difference between *A* and *B* in all three figures are equal, 20 V, so work done by any charge in moving from *A* to *B* surface will be equal.

Q. 5. The work done to move a charge along an equipotential surface from A to B

(A) cannot be defined.

(B) is a negative quantity.

(C) is zero.

(D) is a positive quantity.

Ans. Option (C) is correct.

> ***Explanation:*** For an equipotential surface, $V_A = V_B$
> So, work done = 0

Q. 6. The shape of equipotential surfaces due to an isolated charge is

(A) Concentric spherical shells and the distance between the shells increases with the decrease in electric field

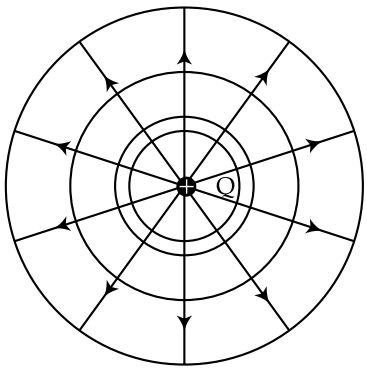
(B) Concentric spherical shells and the distance between the shells decreases with the decrease in electric field

(C) Equi-spaced concentric spherical shells

(D) Changes with the polarity of the charge.

Ans. Option (A) is correct.

> ***Explanation:*** Concentric spherical shells and the distance between the shells increases with the decrease in electric field. It does not depend on the polarity of the charge.



Q. 7. Electric potential inside a conducting sphere

(A) is zero.

(B) remains constant.

(C) decreases from centre to surface.

(D) increases from centre to surface.

Ans. Option (B) is correct.

> ***Explanation:*** Inside the sphere, E = 0
> Again $E = -dV/dr$
> So, $dV/dr = 0$
> This is possible when V is constant.

Q. 8. The electric potential at a point on the equatorial line of a electric dipole is

(A) directly proportional to the square of the distance.

(B) indirectly proportional to the square of the distance.

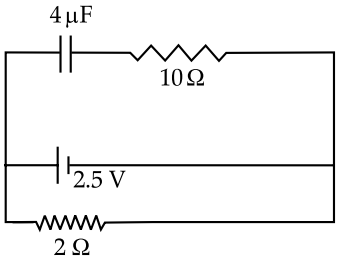
(C) directly proportional to the charge.

(D) None of the above

Ans. Option (D) is correct.

> ***Explanation:*** The electric potential at a point on the equatorial line of a electric dipole is zero.

Q. 9. A capacitor of 4 μF is connected as shown in the circuit Figure. The internal resistance of the battery is 0.5 Ω. The amount of charge on the capacitor plates will be :



(A) 0 μC **(B)** 4 μC
(C) 16 μC **(D)** 8 μC

[NCERT Exemp. Q. 2.1, Page 10]

Ans. Option (D) is correct.

Explanation: As capacitor offer infinite resistance for DC circuit. So current from cell will not flow across branch of 4 μF and 10 Ω. So current will flow across 2 ohm branch.

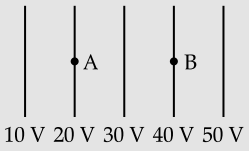


Fig. (i)

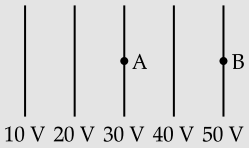


Fig. (ii)

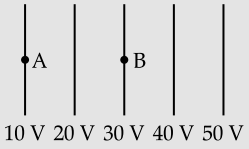
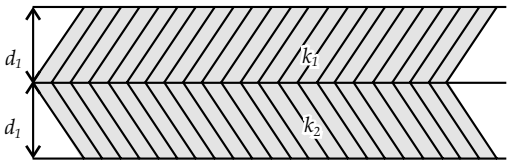


Fig. (iii)

So Potential Difference (PD) across 2 Ω resistance V = RI = 2 × 1 = 2 Volt. As battery, capacitor and 2 branches are in parallel. So PD will remain same across all three branches. As current does not flow through capacitor branch, so no potential drop will be across 10 Ω. So PD across 4 μF capacitor = 2 Volt Q = CV = 2 μF × 2 V = 8 μC

Q. 10. A parallel plate capacitor is made of two dielectric blocks in series. One of the blocks has thickness d_1 and dielectric constant k_1 and the other has thickness d_2 and dielectric constant k_2 as shown in Figure. This arrangement can be thought as a dielectric slab of thickness d ($= d_1+d_2$) and effective dielectric constant k. The k is :



(A) $\frac{k_1d_1+k_2d_2}{d_1+d_2}$ **(B)** $\frac{k_1d_1+k_2d_2}{k_1+k_2}$

(C) $\frac{k_1k_2(d_1+d_2)}{(k_1d_1+k_2d_2)}$ **(D)** $\frac{2k_1k_2}{k_1+k_2}$

Ans. Option (C) is correct.

Explanation: Capacitance of a parallel plate capacitor filled with dielectric of constant k_1 and thickness d_1 is,

$$C_1 = \frac{k_1\varepsilon_0 A}{d_1}$$

Similarly, for other capacitance of a parallel plate capacitor filled with dielectric of constant k_2 and thickness d_2 is,

$$C_2 = \frac{k_2\varepsilon_0 A}{d_2}$$

Both capacitors are in series so equivalent capacitance C is related as :

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{d_1}{k_1\varepsilon_0 A} + \frac{d_2}{k_2\varepsilon_0 A}$$

$$= \frac{1}{\varepsilon_0 A}\left[\frac{k_2d_1 + k_1d_2}{k_1k_2}\right]$$

$$\text{So, } C = \frac{k_1k_2\varepsilon_0 A}{(k_1d_2 + k_2d_1)} \quad \ldots(i)$$

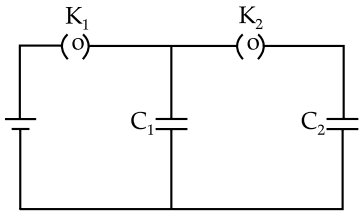
$$C' = \frac{k\varepsilon_0 A}{d} = \frac{k\varepsilon_0 A}{(d_1+d_2)} \quad \ldots(ii)$$

where, $d = (d_1+d_2)$

Comparing eqns. (i) and (ii), the dielectric constant of new capacitor is :

$$k = \frac{k_1k_2(d_1+d_2)}{(k_1d_2 + k_2d_1)}$$

Q. 11. In the circuit shown in Figure, initially key K_1 is closed and key K_2 is open. Then K_1 is opened and K_2 is closed. Then



(A) Voltage across C_1 = Voltage across C_2

(B) Voltage across C_1 > Voltage across C_2 , if $C_1 > C_2$

(C) Charge on C_1 = charge on C_2

(D) None of the above

Ans. Option (A) is correct.

> ***Explanation:*** Since C_1 and C_2 are in parallel, Voltage across C_1 = Voltage across C_2

Q. 12. Capacitance of a parallel plate capacitor can be increased by

(A) increasing the distance between the plates.

(B) decreasing the distance between the plates.

(C) decreasing the area of plates.

(D) increasing the thickness of the plates.

Ans. Option (B) is correct.

> ***Explanation:*** $C = k\varepsilon_0 A / d$
> So, capacitance does not increase by increasing the distance between the plates (d) or decreasing the area of the plates (A). Thickness of plates has no connection with the capacitance of the capacitor.

Q. 13. A parallel plate capacitor is charged by connecting it to a battery. Which of the following will remain constant if the distance between the plates of the capacitor is increased in this situation?

(A) Energy stored

(B) Electric field

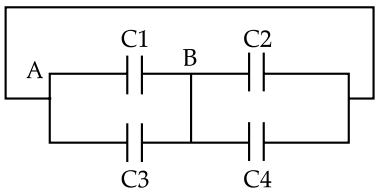
(C) Potential difference

(D) Capacitance

Ans. Option (C) is correct.

> ***Explanation:*** As the battery remains connected with the capacitor, the potential difference remain constant.

Q. 14. 4 capacitors, each of 2 μF, are connected as shown. What will be the equivalent capacitor across the points A, B?



(A) 0.5 μF **(B)** 2 μF

(C) 8 μF **(D)** 4 μF

Ans. Option (C) is correct.

> ***Explanation:*** All the capacitors are connected in parallel. So the equivalent capacitance will be 8 μF.

Q. 15. The capacitance of a parallel plate capacitor is 10 μF. When a dielectric plate is introduced in between the plates, its potential becomes 1/4th of its original value. What is the value of the dielectric constant of the plate introduced?

(A) 4 **(B)** 40

(C) 2.5 **(D)** none of the above

Ans. Option (A) is correct.

> ***Explanation:*** $C' = KC$ (where K is the dielectric constant).
> $V = Q/C$
> $V' = Q/C'$
> $V' = V/4 = Q/C' = Q/KC = V/K$
> $\therefore \quad K = 4$

Q. 16. Two spheres are separately charged and then brought in contact, so

(A) total charge on the two spheres is conserved.

(B) total energy of the two spheres is conserved.

(C) Both (a) and (b)

(D) None of the above

Ans. Option (A) is correct.

> ***Explanation:*** According to the law of conservation of charge, total charge on the two spheres is conserved.

ASSERTION AND REASON BASED MCQs (1 Mark each)

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

Q. 1. Assertion (A): Electric field is always normal to equipotential surfaces and along the direction of decreasing order of potential.

Reason (R): Negative gradient of electric potential is electric field. **[CBSE SQP 2020-21]**

Ans. Option (A) is correct.

> ***Explanation:*** $\vec{E} = -\vec{\nabla} V$
>
> So, The electric field is always perpendicular to equipotential surface.
>
> Negative gradient of electric potential is electric field. So, direction of electric field must be in the direction of the decreasing order of electric potential.

Q. 2. Assertion (A): Electric field inside a hollow conducting sphere is zero.

Reason (R): Charge is present on the surface of conductor.

Ans. Option (A) is correct.

Explanation: Since no charge resides in the surface of a hollow sphere, the electric field also zero inside. So assertion is true.
For hollow conducting sphere, the charged reside on the surface only. So, reason is also true and it explains the assertion properly.

Q. 3. Assertion (A): Work done in moving a charge between any two points in a uniform electric field is independent of the path followed by the charge between these two points.

Reason (R): Electrostatic forces are non-conservative.

Ans. Option (C) is correct.

Explanation: Work done in moving a charge between any two points in a uniform electric field = charge × potential difference. So, it is independent of the path followed by the charge. Hence the assertion is true.
Electrostatic forces are conservative type. Hence, the reason is false.

Q. 4. Assertion (A): Electric potential and electric potential energy are two different quantities.

Reason (R): For a test charge Q and a point charge Q, the electric potential energy becomes equal to the potential.

Ans. Option (C) is correct.

Explanation: Electric potential and electric potential energy are two different quantities. Hence the assertion is true.
Electric potential is defined as the potential energy per unit charge. Hence V = P.E./q
So, the reason is false.

Q. 5. Assertion (A): When the distance between the parallel plates of a parallel plate capacitor is halved and the dielectric constant of the dielectric used is made three times, then the capacitance becomes three times.

Reason (R): Capacitance does not depend on the nature of material.

Ans. Option (B) is correct.

Explanation: Initial capacitance = $C_1 = \frac{A\varepsilon_0 k}{d}$

Finally the capacitance = $C_2 = \frac{A\varepsilon_0 3k}{(d/2)}$

So, $C_2 = 6C_1$
Hence the assertion is true.
From the expression of the capacitance, we find that capacitance depends on the area of the plates, dielectric constant and the distance between the plates. It does not depend on the nature of the material of the plates. Hence the reason is also true.
But the reason cannot explain the assertion.

Q. 6. Assertion (A): Circuit containing capacitors should be handled very carefully even when the power is off.

Reason (R): The capacitors may break down at any time.

Ans. Option (C) is correct.

Explanation: Even when power is off capacitor may have stored charge which may discharge through human body and thus one may get a shock.
So, assertion is true.
Breakdown of capacitors requires high voltage. So, reason is false.

Q. 7. Assertion (A): Capacity of a conductor is independent on the amount of charge on it.

Reason (R): Capacitance depends on the dielectric constant of surrounding medium, shape and size of the conductor.

Ans. Option (A) is correct.

Explanation: $C = \frac{A\varepsilon_0}{d}$

In the expression, there is no involvement of charge. So, capacitance is independent of charge. Hence the assertion is true.
It depends on permittivity of the surrounding medium and the area of the plate. So, reason is also true.
Reason explains the assertion.

Q. 8. Assertion (A): Two parallel metal plates having charge +Q and –Q are facing at a distance between them. The plates are now immersed in kerosene oil and the electric potential between the plates decreases.

Reason (R): Dielectric constant of kerosene oil is less than 1.

Ans. Option (C) is correct.

Explanation: Electric field for parallel plate capacitor in vacuum = $E = \sigma/\varepsilon_0$
Electric field in dielectric = $E' = \sigma/K\varepsilon_0$.
Since the value of K for Kerosene oil is greater than 1, then $E' < E$. Hence the assertion is true.
Dielectric constant of Kerosene oil is greater than 1. Hence the reason is false.

CASE-BASED MCQs

Attempt any 4 sub-parts out of 5. Each question carries 1 mark.

I. Read the following text and answer the following questions on the basis of the same:

Super capacitor: Super capacitor is a high capacity capacitor with a capacitance value much higher than normal capacitors but with lower voltage limits. Such capacitors bridges the gap between electrolytic capacitors and rechargeable batteries.

In automobile, bus, train, crane, elevator such capacitors are used for regenerative braking, short term energy storage or burst-mode power delivery.

Super capacitors have many advantages over batteries: they are very low weight and generally don't contain harmful chemicals or toxic metal. They can be charged and discharged innumerable number of times without ever wearing out.

The disadvantage is that super capacitors aren't well-suited for long-term energy storage. The discharge rate of super capacitors is significantly higher than lithium-ion batteries; they can lose as much as 10-20% of their charge per day due to self-discharge.

Q. 1. Capacity of super capacitor is:

(A) very low. **(B)** medium.

(C) very high. **(D)** may have any value.

Ans. (i) Option (C) is correct.

> ***Explanation:*** Super capacitor is a high capacity capacitor with a capacitance value much higher than normal capacitors but with lower voltage limits. **1**

Q. 2. Super capacitor makes a bridge between:

(A) electrolytic capacitor and rechargeable battery.

(B) single use battery and electrolytic capacitor.

(C) electrolytic capacitor and dynamo.

(D) electrolytic and non-electrolytic capacitors.

Ans. (ii) Option (A) is correct.

> ***Explanation:*** Such capacitors bridges the gap between electrolytic capacitors and rechargeable batteries. **1**

Q. 3. Super capacitors can be charged and discharged:

(A) few number of times.

(B) once only.

(C) several number of times but less than rechargeable batteries.

(D) several number of times much more than rechargeable batteries.

Ans. (iii) Option (D) is correct.

> ***Explanation:*** Super capacitors can be charged and discharged innumerable number of times without ever wearing out. **1**

Q. 4. Self-discharge rate of Super capacitors:

(A) 10-20% of their charge per day

(B) 1 - 2% of their charge per day

(C) 0% of their charge per day

(D) 100% of their charge per day

Ans. (iv) Option (A) is correct.

> ***Explanation:*** The disadvantage is that super capacitors aren't well-suited for long-term energy storage. The discharge rate of super capacitors is significantly higher than lithium-ion batteries; they can lose as much as 10-20% of their charge per day due to self-discharge. **1**

Q. 5. Super capacitors are used for

(A) degenerative braking.

(B) regenerative braking.

(C) small appliances.

(D) long time charge storage.

Ans. (v) Option (B) is correct.

> ***Explanation:*** In automobile, bus, train, crane, elevator such capacitors are used for regenerative braking, short term energy storage or burst-mode power delivery. **1**

II. Read the following text and answer the following questions on the basis of the same:

Capacitor Colour Code:

Capacitor values as written on small capacitors are sometimes misleading. Letters like p (pico) or n (nano) are used in place of the decimal point to identify its position and the value of the capacitor.

For example, a capacitor labelled as n33 = 0.33nF, 8n2 = 8.2nF, 22n = 47nF and so on.

Sometimes capacitors are marked with the capital letter K to signify a value of Kilo pico-Farads. As for example, a capacitor with the markings of 100K would be 1000 × 100 pF = 100 Kpf = 100 nF.

Sometimes, a three letter code consists of the two value digits and a multiplier. For example, the digits 471 = 47 × 10 = 470 pF, 332 = 33 × 100 = 3300 pf.

To reduce these confusions an International colour coding scheme was developed almost same as that of resistance colour code.

Band	Digit 1	Digit 2	Multiplier
Colour			
Black	0	0	x1
Brown	1	1	x10
Red	2	2	x100
Orange	3	3	x1,000
Yellow	4	4	x10,000
Green	5	5	x1000,00
Blue	6	6	x1,000,000
Violet	7	7	
Grey	8	8	x0.01
White	9	9	x0.1

The value obtained from colour code is in pf.

Q. 1. What is the value of the capacitor if n27 is written on it?

(A) 0.27 nF **(B)** 0.27 pF

(C) 27 nF **(D)** 27 pF

Ans. Option (A) is correct.

Q. 2. Two capacitors marked as 221 and 220 respectively are joined in parallel. What is the total capacitance value?

(A) 441 pF **(B)** 242 pF

(C) 242 nF **(D)** 441 nF

Ans. Option (B) is correct.

> ***Explanation:*** The value of the capacitor marked as 221 is 220 pF. The value of the capacitor marked as 220 is 22 pF. When connected in parallel, the total capacitance = 220 pF + 22 pF = 242 pF.

Q. 3. 68k is written on a capacitor. What is its value?

(A) 68 pF **(B)** 68 nF

(C) 68 μF **(D)** None of these.

Ans. Option (D) is correct.

> ***Explanation:*** The value of the capacitor = 1000 × 68 pF = 68 kpF = 68 nF

Q. 4. What is the value of the capacitor bearing a colour code: brown, green, brown?

(A) 15 pF **(B)** 15 nF

(C) 15 nF **(D)** 150 pF

Ans. Option (D) is correct.

> ***Explanation:*** Brown, Green, Brown 15 × 10 = 150 pF

Q. 5. What will be the colour code of a 27 nF capacitor?

(A) Red, violet, black **(B)** Red, violet, brown

(C) Red, violet, orange **(D)** None of the above

Ans. Option (C) is correct.

> ***Explanation:*** Red, violet, orange → 27 × 1000 = 27000 pF = 27 nF

III. Read the following text and answer the following questions on the basis of the same:

Power factor corrector capacitor

Power factor correction is a method to reduce the lagging power factor in inductive loads by fixing a high value capacitor across the phase and neutral line close to the load. When the Voltage and Current are in phase with each other in an AC circuit, the energy from the source is fully converted into another form to drive the load and in this case power factor is in unity. When the power factor drops, the system becomes less efficient.

In inductive loads, current "lags" the voltage leading to "lagging power factor". Power factor correction is the method to reduce the lagging power factor in inductive loads by fixing a high value capacitor across the phase and neutral close to the load. These capacitors have leading power factor so that it will neutralize the lagging power factor of the load.

Power capacitors are huge non polarized metal film electrolytic type capacitors.

Capacitors should be sufficiently rated to the load capacity. It should be connected to the lines, only when the loads are running and drawing current

Q. 1. What is meant by power factor correction?

(A) The method to reduce the lagging power factor in inductive loads

(B) The method to enhance the lagging power factor in inductive load

(C) The method to reduce the lagging power factor in capacitive loads

(D) The method to enhance the lagging power factor in capacitive loads

Ans. Option (A) is correct.

> ***Explanation:*** Power factor correction is the method to reduce the lagging power factor in inductive loads by fixing a high value capacitor across the phase and neutral close to the load.

Q. 2. When the energy from source is fully converted into another form, the power factor is

(A) 0.5 **(B)** 1.0

(C) 0 **(D)** ∞

Ans. Option (B) is correct.

> ***Explanation:*** When the voltage and current are in phase with each other in an AC circuit, the energy from the source is fully converted into another form to drive the load and in this case, power factor is unity. When the power factor drops, the system becomes less efficient.

Q. 3. Power capacitors for power factor correction are

(A) polarized metal film electrolytic type.

(B) non-polarized metal film electrolytic type.

(C) non-polarized metal film non-electrolytic type.

(D) polarized ceramic non- electrolytic type.

Ans. Option (B) is correct.

> ***Explanation:*** Power capacitors are huge non polarized metal film electrolytic type capacitors.

Q. 4. Power capacitors for power factor correction have

(A) lagging power factor.

(B) leading power factor.

(C) leading or lagging power factor depending on the value of the capacitor.

(D) leading or lagging power factor depending on the type of load.

Ans. Option (B) is correct.

> ***Explanation:*** Power factor corrector capacitors have leading power factor so that they neutralize the lagging power factor of the inductive load.

Q. 5. Power factor corrector capacitors should be connected

(A) across the phase and ground near the inductive load.

(B) across the phase and neutral away from the inductive load.

(C) across the phase and neutral near the inductive load.

(D) across the neutral and ground near the inductive load.

Ans. Option (C) is correct.

> ***Explanation:*** Power capacitors are connected across the phase and neutral near the inductive load such as motor.

❑❑

PART – II : CURRENT ELECTRICITY

CHAPTER 3

Term-I

CURRENT ELECTRICITY

Syllabus

- *Electric current, flow of electric charges in a metallic conductor, drift velocity, mobility and their relation with electric current; Ohm's law, electrical resistance, V-I characteristics (linear and nonlinear), 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 laws and simple applications, Wheatstone bridge, metre bridge(qualitative ideas only). Potentiometer - principle and its applications to measure potential difference and for comparing EMF of two cells; measurement of internal resistance of a cell* ***(qualitative ideas only)***

STAND ALONE MCQs (1 Mark each)

Q. 1. Consider a current carrying wire (current I) in the shape of a circle. Note that as the current progresses along the wire, the direction of j (current density) changes in an exact manner, while the current I remain unaffected. The agent that is essentially responsible for is

(A) source of emf.

(B) electric field produced by charges accumulated on the surface of wire.

(C) the charges just behind a given segment of wire which push them just the right way by repulsion.

(D) the charges ahead.

Ans. Option (B) is correct.

> ***Explanation:*** As we know that current density (J) depends on
> (i) conductivity [$\sigma = 1/\rho = 1/R.A$]
> (ii) Electric field [$J = \sigma E$]
> (iii) current, length and area of cross-section
> But in the given options only B, that is, electric field can be varied by the charges accumulated on the surface of wire.

Q. 2. Which of the following characteristics of electrons determines the current in a conductor?

(A) Drift velocity alone

(B) Thermal velocity alone

(C) Both drift velocity and thermal velocity

(D) Neither drift nor thermal velocity.

Ans. Option (A) is correct.

> ***Explanation:*** As we know that,
> $I = Ane Vd$
> So current,
> $I \alpha Vd$
> And, current (I) also depend on n, the number of free electrons which increases on increasing temperature which makes more collision between electrons and increases resistance or decrease current.

Q. 3. A metal rod of length 10 cm and a rectangular cross-section of 1 cm $\times \frac{1}{2}$ cm is connected to a battery across opposite faces. The resistance will be

(A) maximum when the battery is connected across 1 cm $\times \frac{1}{2}$ cm faces.

(B) maximum when the battery is connected across 10 cm $\times$ 1 cm faces.

(C) maximum when the battery is connected across 10 cm $\times \frac{1}{2}$ cm faces.

(D) same irrespective of the three faces.

Ans. Option (A) is correct.

Explanation: As we know that,

$$R = \rho\left(\frac{l}{A}\right)$$

The maximum resistance will be achieved when the value of $\frac{l}{A}$, is maximum, so that 'A' must be minimum and it is minimum when area of cross section is 1 cm × $\frac{1}{2}$ cm.

Q. 4. When cell of e.m.f. E is connected with an external resistance R, the p.d. across the cell becomes V. The expression for the internal resistance of the cell is]

(A) $\frac{E-V}{V}R$ **(B)** 10^{23}

(C) $\frac{V-E}{V}R$ **(D)** $\frac{V-E}{E}R$

Ans. Option (A) is correct.

Explanation: Current in the circuit = I = V/R
If r = internal resistance of the cell, then V = E – Ir

$$\therefore r = \frac{E-V}{I} = \frac{E-V}{V/R} = \frac{E-V}{V}R$$

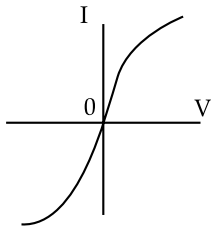
Q. 5. The current density (number of free electrons per m^3) in metallic conductor is of the order of

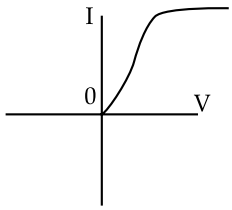
(A) 10^{28} **(B)** 10^{23}
(C) 10^{20} **(D)** 10^{15}

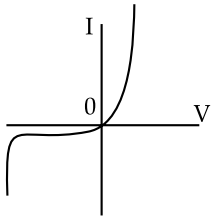
Ans. Option (A) is correct.

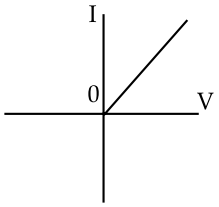
Explanation: The current density (number of free electrons per m^3) in metallic conductor is of the order of 10^{28}.

Q. 6. Which of the following I-V characteristic represent the characteristic of a Ohmic conductor?

(A)


(B)


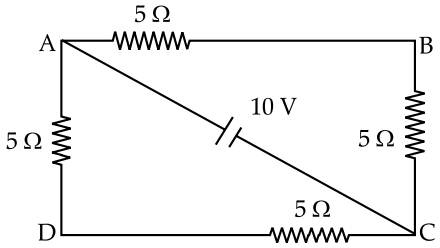
(C)


(D)


Ans. Option (D) is correct.

Explanation: Slope of I-V characteristic of an Ohmic conductor remains constant throughout.

Q. 7. What is the potential difference between points A and B in the following circuit?

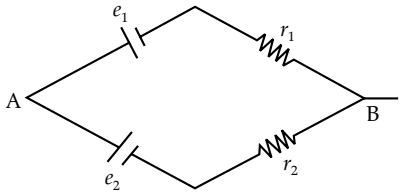


(A) 10 V **(B)** 5 V
(C) 2.5 V **(D)** 20 V

Ans. Option (B) is correct.

Explanation: Equivalent resistance of the circuit = (5 + 5) || (5 + 5) = 5 Ω
Total circuit current = 10/5 = 2 A
Current in each branch is 1A
So, potential difference between points A and B i.e. across the 5Ω resistor is 1 × 5 = 5 V.

Q. 8. Two batteries of emf ε_1 and ε_2 ($\varepsilon_2 > \varepsilon_1$) and internal resistances r_1 and r_2 respectively are connected in parallel as shown in figure :



(A) The equivalent emf ε_{eq} of the two cells is between ε_1 and ε_2, *i.e.* $\varepsilon_1 < \varepsilon_{eq} < \varepsilon_2$.
(B) The equivalent emf ε_{eq} is smaller than ε_1.
(C) The ε_{eq} is given by $\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2$ always.
(D) ε_{eq} is independent of internal resistances r_1 and r_2.

Ans. Option (A) is correct.

Explanation: As we know that the equivalent emf in parallel combination of cells is :

$$\varepsilon_{eq} = \frac{(\varepsilon_1 r_2 + \varepsilon_2 r_1)}{(r_1 + r_2)}$$

so, it is clear that part '*c*' and '*d*' are incorrect by formula. According to this formula only option (A), is correct.

Q. 9. A resistance R is to be measured using a meter bridge. Student chooses the standard resistance S to be 100 Ω. He finds the null point at $l_1 = 2.9$ cm. He is told to attempt to improve the accuracy. Which of the following is a useful way?

(A) He should measure l_1 more accurately.

(B) He should change S to 1000 Ω and repeat the experiment.

(C) He should change S to 3 Ω and repeat the experiment.

(D) He should give up hope of a more accurate measurement with a meter bridge.

Ans. Option (C) is correct.

Explanation: To calculate resistance, R

$$R = S\left[\frac{l_1}{(100 - l_1)}\right]$$

$$= 100\left[\frac{2.9}{97.1}\right]$$

$$= 2.98\ \Omega$$

So to get balance point near to 50 cm (middle) we have to take S = 3 Ω, as here R : S =2.9 : 97.1 implies that S is nearly 33 times to R.

In order to make ratio R and S = 1 : 1, we must take the resistance S = 3 Ω, which verifies options (C).

Q. 10. Two cells of emf's approximately 5 V and 10 V are to be accurately compared using a potentiometer of length 400 cm :

(A) The battery that runs the potentiometer should have voltage of 8 V.

(B) The battery of potentiometer can have a voltage of 15 V and R adjusted so that the potential drop across the wire slightly exceeds 10 V.

(C) The first portion of 50 cm of wire itself should have a potential drop of 10 V.

(D) Potentiometer is usually used for comparing resistances and not voltages.

Ans. Option (B) is correct.

Explanation: Given that,
emf of primary cells are 5 V and 10 V
The potential drop across potentiometer wire must be slightly more than that larger emf 10 V.
So, the battery should be of 15 V and about 4 V potential is dropped by using rheostat or resistances. So option (B) is correct.

Q. 11. Kirchhoff's current law is based on the law of conservation of

(A) charge. **(B)** energy.

(C) mass. **(D)** (B) and (C)

Ans. Option (A) is correct.

Explanation: Kirchhoff's current law is based on the law of conservation of charge.

Q. 12. Kirchhoff's voltage law is based on the law of conservation of

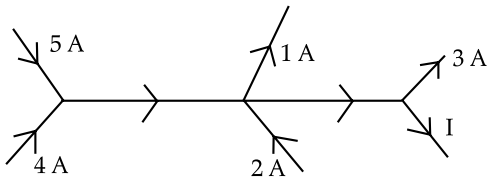
(A) charge **(B)** energy

(C) mass **(D)** (B) and (C)

Ans. Option (B) is correct.

Explanation: Kirchhoff's current law is based on the law of conservation of energy.

Q. 13. Apply Kirchhoff's law to find the current I in the part of the following circuit.

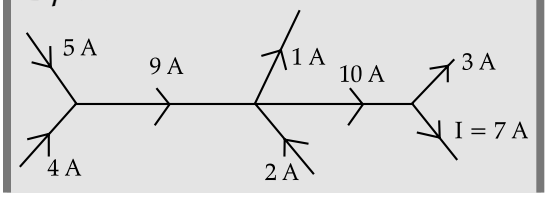


(A) 5 A **(B)** 3 A

(C) 7 A **(D)** 1 A

Ans. Option (C) is correct.

Explanation:



Q. 14. Wheatstone Bridge is not suitable for measurement of

(A) very high value resistances.

(B) very low value resistances.

(C) both (A) and (B).

(D) medium value resistances.

Ans. Option (C) is correct.

Explanation: Wheatstone bridge is suitable for measurement of medium value resistances because to ensure sensitivity, other resistors must be of comparable values.

Q. 15. Kirchhoff's laws are valid for _____.

(A) only passive circuits

(B) only linear circuits

(C) only non-linear circuits

(D) both (B) and (C).

Ans. Option (D) is correct.

Explanation: Kirchhoff's laws are valid for both linear and non-linear circuits.

Q. 16. Two resistances are connected in two gaps of Meter Bridge. The balance is 10 cm from the zero end. A resistance of 20 Ω is connected in series with the smaller of the two. The null point shifts to 20 cm. What is the value of the bigger resistance?

(A) 89 Ω **(B)** 144 Ω

(C) 100 Ω **(D)** None of the above

Ans. Option (B) is correct.

Explanation: **Case 1:** P/Q = 10/90 = 1/9 ...(i)
Case 2: (P+20)/Q = 20/80 = ¼ ...(ii)
Dividing equation (i) by (ii)
P/(P+20) = 4/9
∴ P = 16 Ω
Putting in equation (i)
Q = 144 Ω

Q. 17. In a metre bridge, what is the effect on null deflection of galvanometer, when the radius of the meter bridge wire is doubled?

(A) There will be no change

(B) Null point will shift to L_1 / 2 point

(C) Null point will shift to $2L_1$ point

(D) Null point will not be available

Ans. Option (A) is correct.

Explanation: For a balanced Meter Bridge $P/Q = L_1/(100 - L_1)$.
There is no parameter related to the radius of the wire. So, the null deflection of galvanometer does not depend on the radius of the wire. So, even if the radius of the wire is doubled, the null deflection of the galvanometer will not be changed.

Q. 18. Consider a metre bridge whose length of wire is 2m. A resistance of 10 Ω is connected across one gap of the meter bridge and an unknown resistance is connected across the other gap. When these resistances are interchanged, the balance point shifts by 50 cm. What is the value of the unknown resistance?

(A) 250 Ω **(B)** 10 Ω

(C) 16.7 Ω **(D)** None of the above

Ans. Option (C) is correct.

Explanation: Say, the unknown resistance = X
Case 1: $10/X = L_1/(200-L_1)$
Or, $xL_1 = 2000 - 10L_1$ ...(i)
Case 2: $X/10 = (L_1 + 50)/(150-L_1)$
Or, $xL_1 = 150X - 10L_1 - 500$ ...(ii)
Comparing equation (i) and (ii)
X = 2500/150 = 16.7 Ω

Q. 19. Which error of meter bridge is removed when the known and unknown resistances are interchanged?

(A) End error **(B)** Measurement error

(C) Percentage error **(D)** Parallax error

Ans. Option (A) is correct.

Explanation: End error of metre bridge is removed when the known and unknown resistances are interchanged.

Q. 20. In a potentiometer of 5 wires, the balance point is obtained on the 3rd wire. To shift the balance point to the 4th wire,

(A) current of the main circuit is to be decreased.

(B) current of the main circuit is to be increased.

(C) the shifting is not possible

(D) None of the above

Ans. Option (A) is correct.

Explanation: To shift the balance point of a potentiometer to a higher length, the potential gradient of the wire is to be decreased. This can also be achieved by decreasing the current of the main circuit. So, this is a true statement.

Q. 21. Which one of the following statements is correct?

(A) Potentiometer is used to measure the current in a circuit.

(B) Potentiometer is used to measure the internal resistance of a cell.

(C) Potentiometer is used to measure the resistance of a circuit.

(D) Potentiometer is used to measure the potential difference across a resistor.

Ans. Option (B) is correct.

Explanation: Potentiometer is used to measure internal resistance of a cell, e.m.f. of a cell and to compare the e.m.f.'s of

ASSERTION AND REASON BASED MCQs (1 Mark each)

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

Q. 1. Assertion (A): Fuse wire has high resistance and low melting point.

Reason (R): Fuse wire is for small current flow only.

Ans. Option (C) is correct.

Explanation: Fuse wire should melt and disconnect the circuit from mains supply if the current increases beyond a rated value. For this reason, its resistance should be high for more heat generation and melting point should be low for fast melting. So assertion is correct.

Fuse wire is not for small current flow. Fuse wire may be of various current rating depending on the type of appliance being used and the capacity of the wiring. So, the reason is false. 1

Q. 2. Assertion (A): Electric appliance with metal body has three electrical connections. But an electrical bulb has two electrical connection.

Reason (R): Three pin connection reduces chances of electrical shocks.

Ans. Option (A) is correct.

Explanation: The metallic body of electrical appliance is connected to the 3rd pin which is an earth pin.

By any chance if the metallic body gets connected to the LIVE line, current flows to earth through this pin without giving any shock to the user.

Hence assertion is true.

Electric bulb does not have any metallic encloser and hence there is no requirement of earth pin. So, the reason is also true and properly explains the assertion.

Q. 3. Assertion (A): The resistance of superconductor is zero.

Reason (R): Super conductors are used for electrical power transmission.

Ans. Option (B) is correct.

Explanation: Resistance of superconductor falls to zero at critical temperature.

This property is very useful for power transmission without any loss.

Assertion and reason both are true but reason does not explain the assertion.

Q. 4. Assertion (A): The same amount of current flows through the filament and line wire. But more heat is produced in filament.

Reason (R): Filament is made of material having high resistance and high melting point.

Ans. Option (A) is correct.

Explanation: Heat produced = H = i^2Rt

H ∝ R

Since resistance of filament >> Resistance of wire so more heat is produced in filament. Therefore, Assertion is true. Filament is made of material having high resistance like tungsten so that heat produced is more.

Melting point of the material also should be high so that it can sustain more heat. Hence reason is also true. Reason properly explains the assertion.

Q. 5. Assertion (A): Power rating of resistance is not so important when used in a circuit.

Reason (R): The resistance value changes with temperature.

Ans. Option (D) is correct.

Explanation: Power rating describes the heat dissipation capability of the resistor. If the heat generated is more than the power rating of the resistor, it will burn. So assertion is false. Resistance value is temperature dependent. So, the reason is true, But reason does not explain the assertion.

Q. 6. Assertion (A): Kirchhoff's junction rule is applicable for any number of lines meeting at a point in an electrical circuit.

Reason (R): When there is a flow of steady current, then there is no accumulation of charge at the junction.

Ans. Option (A) is correct.

Explanation: Kirchhoff's junction rule is applicable at any point of an electrical circuit and there is no limitation of number of lines meeting at that point. So the assertion is true.

While steady current is flowing there is no accumulation of charge at the junction. Total incoming charge = total outgoing charge. So the reason is also true and explains the assertion.

Q. 7. Assertion (A): Kirchhoff's voltage law indicates that the electric field is conservative.

Reason (R): Potential difference between two points in a circuit does not depend on the path.

Ans. Option (A) is correct.

Explanation: Kirchhoff's voltage law says that the sum of the voltages around any closed loop is zero. A closed loop starts from a node, traces a path through the circuit and returns to the same node. Since the total work done in moving a charge around this close path the zero, hence the electric field is conservative. So, the assertion is true.

Potential difference between two points in a circuit does not depend on the path. This is true for conservative field. Hence the reason is also true and it explains the assertion.

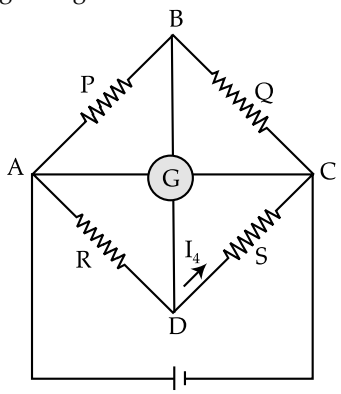
Q. 8. Assertion (A): In balanced condition, if the galvanometer and the voltage source is interchanged, the balanced condition remains same.

Reason (R): The balanced condition of Wheatstone bridge does not depend on the value of the resistances.

Ans. Option (C) is correct.

Explanation: In balanced condition, if the galvanometer and the voltage source are interchanged, the balanced condition remains same since in both the cases R_1R_4 remains equal to R_2R_3 . The assertion is true.
The balanced condition of Wheatstone bridge depends on the value of the resistances. R_1R_4 should be equal to R_2R_3. So, if the resistance values are changed, the balanced condition also gets disturbed. So, the reason is false.

Q. 9. Assertion (A): In balanced condition of a Wheatstone bridge, there is no current flow through the galvanometer.



Reason (R): The potential of point B and D are same.

Ans. Option (A) is correct.

Explanation: In balanced condition of a Wheatstone bridge, there is no current flow through the galvanometer. This is also called null condition. So, the assertion is true.
When the potential of point B and D are same then only there is no current flow through the galvanometer. Hence the reason is also true and explains the assertion.

Q. 10. Assertion (A): A high resistance is connected in series with the galvanometer of meter bridge.

Reason (R): As resistance increases, the current also increases.

Ans. Option (C) is correct.

Explanation: Resistance of galvanometer is low. So, to protect it from damage a high resistance is connected in series with it which limits the flow of current through it. So the assertion is true.
From Ohms law, I = V/R. So as resistance increases, the current decreases. Hence the reason is false.

Q. 11. Assertion (A): Meter bridge wire is generally made of Constantan.

Reason (R): Constantan has a very low temperature coefficient of resistance.

Ans. Option (A) is correct.

Explanation: Meter bridge wire is generally made of Constantan. The assertion is true.
Temperature coefficient of resistance of Constantan is very low. So, its resistance variation is negligible even after long use. This is the requirement of an ideal meter bridge. So the reason is true and properly explains the assertion.

Q. 12. Assertion (A): The balancing point of a meter bridge is obtained at L = 40 cm. When the area of cross-section of the wire of is doubled, the balancing point shifts to L = 60 cm.

Reason (R): Resistance of wire is directly proportional to its area of cross-section .

Ans. Option (D) is correct.

Explanation: For a meter bridge, at the balancing point $\frac{R}{X}=\frac{L}{100-L}$ which is independent of the area of cross section. So, the assertion is false.
Resistance of wire is inversely proportional to its area of cross-section since R = $R=\rho\frac{L}{A}$. So reason is also false.

Q. 13. Assertion (A): Potentiometer is used to measure the e.m.f. of a cell.

Reason (R): Potentiometer is preferred over voltmeter to measure the e.m.f. a cell since it does not draw any net current from the cell.

Ans. Option (A) is correct.

Explanation: Potentiometer is used to measure the e.m.f. of a cell. The assertion is true.
Voltmeter draws certain amount of current from the cell. So, V = E – iR. The measured value by the voltmeter is less than the actual e.m.f. of the cell. But potentiometer draws no net current at balance point, hence it measures the actual e.m.f. of the cell. So, the reason is also true and explains the assertion properly.

CASE-BASED MCQs

Attempt any 4 sub-parts out of 5. Each sub-part carries 1 mark.

I. Read the following text and answer the following questions on the basis of the same:

Electric Toaster : Small Industries Service Institute Takyelpat Industrial Estate Imphal has designed an Electric toaster which is operated at 220 volts A.C., single phase and available in four different rated capacity such as 600 W, 750 W, 1000 W and 1250 W.

The heating element is made of nichrome 80/20 (80% nickel, 20% chromium), since Nichrome does not get oxidise readily at high temperature and have higher resistivity, so it produces more heat.

The element is wound separately on Mica sheets and fitted with body of toaster with the help of ceramic terminals.

Q. 1. Heating element of the toaster is made of :

(A) copper. **(B)** nichrome.

(C) chromium. **(D)** nickel.

Ans. Option (B) is correct.

> ***Explanation:*** The heating element is made of nichrome 80/20 (80% nickel, 20% chromium).

Q. 2. What is meant by 80/20 Nichrome?

(A) 80% Chromium and 20% Nickel

(B) 80% Nickel and 20% Chromium

(C) Purity 80%, Impurity 20%

(D) It is a mixture of Chromium and Nickel

Ans. Option (B) is correct.

> ***Explanation:*** Nichrome 80/20 means an alloy of 80% nickel, 20% chromium.

Q. 3. Which one will consume more electricity?

(A) 600 W **(B)** 750 W

(C) 1000 W **(D)** 1200 W

Ans. Option (D) is correct.

> ***Explanation:*** Electricity consumption is measured by kWH. So, 1200W toaster will consume more electricity.

Q. 4. Operating voltage of the device is :

(A) 220 V AC, single phase

(B) 220 V AC, three phase

(C) 220 V DC

(D) 220 V AC/DC

Ans. Option (A) is correct.

> ***Explanation:*** The designed electric toaster is operated at 220 volts A.C., single phase.

Q. 5. Insulating materials used in the device are :

(A) Mica

(B) Ceramic

(C) Mica, ceramic, Nichrome

(D) Mica, ceramic

Ans. Option (D) is correct.

> ***Explanation:*** The element is wound separately on Mica sheets and fitted with body of toaster with the help of ceramic terminals.

II. Read the following text and answer the following questions on the basis of the same:

Shunt resistance:

The ammeter shunt is the device which provides the low resistance path to the flow of current. It is connected in parallel with the ammeter. In some ammeter the shunt is in-built inside the instrument while in others it is externally connected to the circuit.

Ammeters are designed for measurement of low current. For measuring high current, the shunt is connected in parallel to the ammeter. The significant portion of the current passes to the shunt because of the low resistance path and little amount of current passes through the ammeter.

The shunt is connected in parallel to the ammeter because of which the voltage drops across the meter and shunt remain the same. Thus, the movement of the pointer is not affected by the shunt.

Let us consider that the current to be measured is I. The circuit has ammeter and shunt connected parallel to each other. The ammeter is designed for measurement of small current say, I_m. The magnitude of the current I passes through the meter is very high, and it will burn the meter. So, for measuring the current I the shunt is required in the circuit.

As the shunt connects in parallel with the ammeter, thus the same voltage drops occur between them:

$$I_{Sh}R_{SH} = I_mR_m$$

$$\therefore \quad R_{SH} = I_mR_m/I_{SH}$$

Shunt current $I_{SH} = I - I_m$

So, $R_{SH} = I_mR_m/(I - I_m)$

$$\therefore \quad I/I_m = 1 + (R_m/R_{SH})$$

The ratio of the total current to the current required for the movement of the ammeter coil is called the multiplying power of the shunt.

$\therefore$ The multiplying power $= m = I/I_m$

$$R_{SH} = R_m / (m - 1)$$

The following are the requirements of the shunt.

- The resistance of the shunt should remain constant with time.
- The temperature of the material should remain same even though substantial current flows through the circuit.

Q. 1. Manganin and Constantan are used for making the shunt of DC and AC ammeter respectively.

What is multiplying power of the shunt?

(A) $\dfrac{\text{Total current}}{\text{Current required by the movement of ammeter coil}}$

(B) $\dfrac{\text{Current required by the movement of ammeter coi}}{\text{Total current}}$

(C) Current required by the movement of ammeter coil X Total current

(D) None of the above

Ans. Option (A) is correct.

Q. 2. Materials used for making shunt of DC and AC ammeter are respectively

(A) Manganin and Manganin

(B) Manganin and Copper

(C) Manganin and Constantan

(D) Constantan and Manganin

Ans. Option (C) is correct.

Q. 3. Current through shunt is

(A) greater than current through ammeter coil.

(B) less than current through ammeter coil.

(C) equal to the current through ammeter coil.

(D) may be greater than or equal to or less than current through ammeter coil.

Ans. Option (A) is correct.

Q. 4. How shunt is connected with a ammeter?

(A) In series when connected externally

(B) In parallel when connected externally

(C) In parallel when connected internally

(D) Both (B) and (C)

Ans. Option (D) is correct.

Q. 5. What will be the value of the shunt resistance if the ammeter coil resistance is 1Ω and multiplying power is 100?

(A) 1/99Ω **(B)** 99Ω

(C) 101Ω **(D)** 1/101Ω

Ans. Option (A) is correct.

> ***Explanation:*** $R_{SH} = R_m / (m - 1) = 1/(100 - 1) = 1/99\Omega$

III. Read the following text and answer the following questions on the basis of the same:

Types of resistors

Most common type of resistor is Carbon Composition Resistors. Carbon resistors are a cheap, general purpose resistor used in electrical and electronic circuits. Their resistive element is manufactured from a mixture of finely ground carbon dust or graphite and a non-conducting ceramic powder to bind it all together.

The ratio of carbon dust to ceramic (conductor to insulator) determines the resistive value of the resistor. Higher the ratio of carbon, lower the overall resistance.

Film Type Resistors consist of Metal Film, Carbon Film and Metal Oxide Film .Such resistors are generally made by depositing pure metals, such as nickel, or an oxide film, such as tin-oxide, on an insulating ceramic rod or substrate.

The resistive value of the resistor is controlled by increasing the desired thickness of the deposited film giving them the names of either "thick-film resistors" or "thin-film resistors".

Film type resistors can achieve much higher ohmic value compared to other types.

Another type of resistor, called a Wirewound Resistor, is made by winding a thin metal alloy wire (Nichrome) or similar wire on an insulating ceramic former in the form of a spiral helix.

These types of resistors are generally only available in very low ohmic value with high precision .

They are able to handle much higher electrical currents than other resistors of the same ohmic value with much excessive power ratings. These high power resistors are moulded into an aluminium heat sink body with fins attached to increase their overall surface area to promote heat loss and cooling.

Q. 1. Carbon composition resistors are made from a mixture of

(A) finely ground metal dust and ceramic powder.

(B) finely ground carbon dust or graphite and ceramic powder.

(C) finely ground carbon dust or graphite and copper powder.

(D) finely ground carbon dust or graphite.

Ans. Option (B) is correct.

> ***Explanation:*** Carbon Composition Resistors are manufactured from a mixture of finely ground carbon dust or graphite and a non-conducting ceramic powder to bind it all together.

Q. 2. In carbon composition resistors, _____ the ratio of carbon, _____ the overall resistance.

(A) Higher, lower **(B)** Lower, higher

(C) Lower, lower **(D)** Higher, higher

Ans. Option (A) is correct.

> ***Explanation:*** The ratio of carbon dust to ceramic (conductor to insulator) determines the resistive value of the resistor. Higher the ratio of carbon, lower the overall resistance.

Q. 3. Metal Film Type Resistors are generally made by depositing pure _____, on _____ rod or substrate.

(A) Ceramic, metal **(B)** Carbon, ceramic

(C) Metal, ceramic **(D)** Carbon, metal

Ans. Option (C) is correct.

> ***Explanation:*** Metal Film Type Resistors are generally made by depositing pure metals, such as nickel on an insulating ceramic rod or substrate.

Q. 4. Wirewound Resistors are made by winding a thin _____ or similar wire on an ____ former in the form of a spiral helix.

(A) Nichrome, copper **(B)** Nichrome, ceramic

(C) Copper, ceramic **(D)** Copper, Nichrome

Ans. Option (B) is correct.

Explanation: Wirewound Resistor, is made by winding a thin metal alloy wire (Nichrome) or similar wire on an insulating ceramic former in the form of a spiral helix.

Q. 5. Wire wound resistors are available in very ____ ohmic high precision values with _____ power rating.

(A) High, high **(B)** Low, low

(C) High, Low **(D)** Low, high

Ans. Option (D) is correct.

Explanation: Wirewound Resistors are generally only available in very low ohmic high precision values. They are able to handle much higher electrical currents than other resistors of the same ohmic value with much excessive power ratings. These high power resistors are moulded into an aluminium heat sink body with fins attached to increase their overall surface area to promote heat loss and cooling.

❐❐

CHAPTER 4

Term-I

MOVING CHARGES AND MAGNETISM

Syllabus

- *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 and toroidal solenoids (only qualitative treatment), force on a moving charge in uniform magnetic and electric fields. Force on a current-carrying conductor in a uniform magnetic field, force between two parallel current-carrying conductors-definition of ampere, torque experienced by a current loop in uniform magnetic field; moving coil galvanometer-its current sensitivity and conversion to ammeter* and voltmeter.

STAND ALONE MCQs (1 Mark each)

Q. 1. Two charged particles traverse identical helical paths in a completely opposite sense in a uniform magnetic field $\mathbf{B} = B_0\hat{k}$.

(A) They have equal z-components of momenta.

(B) They must have equal charges.

(C) They necessarily represent a particle-antiparticle pair.

(D) The charge to mass ratio satisfy: $\left(\frac{e}{m}\right)_1 + \left(\frac{e}{m}\right)_2 = 0$

Ans. Option (D) is correct.

Explanation: When charge/mass ratio of these two particles is same and charges on them are of opposite nature, then the charged particles will traverse identical helical paths in a completely opposite sense. Therefore, option (D) is correct.

Q. 2. Biot-Savart law indicates that the moving electrons (velocity v) produce a magnetic field B such that

(A) $B \perp v$.

(B) $B \parallel v$.

(C) it obeys inverse cube law.

(D) it is along the line joining the electron and point of observation.

Ans. Option (A) is correct.

Explanation: In Biot-Savart's law, magnetic field $B \parallel idl \times r$ and idl due to flow of electron is in opposite direction of v and by direction of cross product of two vectors, B.

$$dB = \frac{I.dl \sin\theta}{r^2}$$

or $$dB = \frac{I \times dl}{r}$$

According to Biot-Savart law, if magnetic field is not perpendicular to the motion of charge, then it will not move in helical path, which is not possible for motion of a charge in magnetic field. So, the magnetic field is perpendicular to the direction of flow of charge verifies answer 'A'.

Q. 3. A current carrying circular loop of radius R is placed in the $x - y$ plane with centre at the origin. Half of the loop with $x > 0$ is now bent so that it now lies in the $y - z$ plane.

(A) The magnitude of magnetic moment now diminishes.

(B) The magnetic moment does not change.

(C) The magnitude of B at $(0.0.z)$, $z >> R$ increases.

(D) The magnitude of B at $(0.0.z)$, $z >> R$ is unchanged.

Ans. Option (A) is correct.

Explanation : For a circular loop of radius R, carrying current I in x-y plane, the magnetic moment $M = I \times \pi R_2$.
It acts perpendicular to the loop along z-direction.
When half of the current loop is bent in y-z plane, then magnetic moment due to half current loop is x-y plane, $M_1 = I(\pi R_2/2)$ acting along z-direction.
Magnetic moment due to half current loop in y-z plane, $M_2 = I(\pi R_2/2)$ along x-direction.
Net magnetic moment due to entire bent current loop,

$$M_{net} = \sqrt{M_1^2 + M_2^2}$$
$$= \sqrt{2}\,\frac{I\pi R^2}{2}$$
$$= \frac{M}{\sqrt{2}}$$

Therefore, $M_{net} < M$ or M diminishes.

Q. 4. *A* circular current loop of magnetic moment M is in an arbitrary orientation in an external magnetic field B. The work done to rotate the loop by 30° about an axis perpendicular to its plane is

(A) MB **(B)** $\frac{\sqrt{3}MB}{2}$.

(C) $\frac{MB}{2}$. **(D)** zero.

Ans. Option (D) is correct.

Explanation : The work done to rotate the loop in magnetic field, $W = MB(\cos\theta_1 - \cos\theta_2)$.
When current carrying coil is rotated then there will be no change in angle between magnetic moment and magnetic field.
Here, $\theta_1 = \theta_2 = \alpha$
$\Rightarrow W = MB(\cos\alpha - \cos\alpha) = 0$.

Q. 5. When a charge of 1C moving with velocity 1 m/s normal to a magnetic field experiences a force 1 N , then the magnitude of the magnetic field is

(A) 1 Gauss **(B)** 1 Tesla

(C) 1 Orested **(D)** None of the above

Ans. Option (A) is correct.

Explanation : $F = qvB\sin\theta$
When $q = 1$ C, $v = 1$ m/s, $F = 1$ N, $\theta = 90°$,
then B = 1T

Q. 6. An electron is projected with uniform velocity along the axis of a current carrying long solenoid. Which of the following is true?

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

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

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

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

Ans. Option (D) is correct.

Explanation: The magnetic field inside the long current carrying solenoid is uniform. Therefore, magnitude of force on the electron of charge $(-e)$ is given by $F = -evB\sin\theta = 0$ $(\theta = 0°)$ as magnetic field and velocity are parallel. The electron will continue to move with uniform velocity along the axis of the solenoid.

Q. 7. When a charged particle moves through a magnetic field perpendicular to its direction. Then

(A) Linear momentum changes

(B) kinetic energy remains constant

(C) Both (A) and (B)

(D) Both linear momentum and kinetic energy varies

Ans. Option (B) is correct.

Explanation: When a charged particle perpendicularly enters a magnetic field to the direction, the path of the motion is circular. In circular motion, the direction of velocity changes at every point (the magnitude remains constant). Therefore, the linear momentum changes at every point. But kinetic energy remains constant since the magnitude of velocity does not change.

Q. 8. A length L of wire carries a steady current I. It is bent first to form a circular plane coil of one turn. A current I flowing through it produces a magnetic field B at the centre of the coil. The same length is now bent more sharply to form a double loop of smaller radius. The magnetic field at the centre caused by the same current is

(A) B **(B)** 2B

(C) 4B **(D)** B/2

Ans. Option (C) is correct.

Explanation: $B_2 = n^2B_1$
Here $n = 2$, $B_1 = B$.
$\therefore$ $B_2 = 4B$

Q. 9. A straight conductor carries a current from south to north. Point P and Q lie to the east and west of it at the same distance. The magnetic field at P is

(A) equal to magnetic field at Q.

(B) smaller than the magnetic field at Q.

(C) greater than the magnetic field at Q.

(D) cannot be predicted unless the value if I is known.

Ans. Option (A) is correct.

Explanation: $B \propto I$, $B \propto 1/r$
So, if I and r remains constant, then magnetic field at P = Magnetic field at Q.

Q. 10. Magnetic field due to a straight solenoid at any point inside it is $B = \mu_0 ni$. Magnetic field at the end of the solenoid is

(A) B **(B)** B/2

(C) 2B **(D)** B/4

Ans. Option (B) is correct.

Explanation: Magnetic field at the end of a current carrying solenoid is half of the magnetic field inside it.

Q. 11. At any point, empty space surrounded by a toroid, the magnetic field is B_1. At any point, outside the toroid, the magnetic field is B_2.

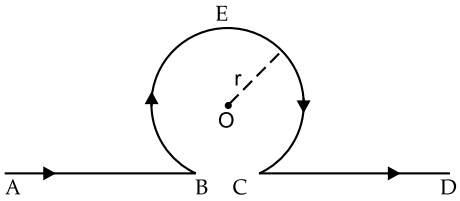
(A) $B_1 > B_2$ **(B)** $B_2 > B_1$

(C) $B_1 = B_2$ **(D)** $B_1 = B_2 = 0$

Ans. Option (D) is correct.

Explanation: As net current is zero, magnetic field at the empty space surrounded by toroid and outside the toroid is zero.

Q. 12. An infinitely long straight conductor is bent into the shape as shown in the figure. Current in it is i and the radius of the circular loop is r. The magnetic field at its centre is



(A) Zero **(B)** Infinite

(C) $\frac{\mu_0 i}{2\pi r}(\pi - 1)$ **(D)** $\frac{\mu_0 i}{2\pi r}(\pi + 1)$

Ans. Option (C) is correct.

Explanation: Magnetic field at O due to ABCD straight conductor = $\frac{\mu_0 i}{2\pi r}$

Magnetic field at O due to the BEC circular conductor = $\frac{\mu_0 i}{2r}$

The fields are in opposite direction. Hence the resultant field at O is $\frac{\mu_0 i}{2r} - \frac{\mu_0 i}{2\pi r} = \frac{\mu_0 i}{2\pi r}(\pi - 1)$

Q. 13. A solenoid of 1.5 metre length and 4.0 cm diameter has 10 turn per cm. A current of 5 A ampere is flowing through it. The magnetic field at axis inside the solenoid is

(A) $2\pi \times 10^{-3}$ T **(B)** $2\pi \times 10^{-3}$ G

(C) $2\pi \times 10^{-7}$ T **(D)** $2\pi \times 10^{-7}$ G

Ans. Option (A) is correct.

Explanation: $B = \mu_0 ni = 4\pi \times 10^{-7} \times 5 \times 10 \times 10^2 = 2\pi \times 10^{-3}$ T

Q. 14. The strength of the magnetic field at distance r from a long straight current carrying wire is B. The field at a distance $r/2$ will be

(A) B **(B)** 2B

(C) B/2 **(D)** B/4

Ans. Option (B) is correct.

Explanation: $B \propto 1/r$

$B_1/B_2 = r_2/r_1 = \frac{r/2}{r}$

$\therefore B_2 = 2B_1 = 2B$

Q. 15. In a moving coil galvanometer, current in the coil is

(A) directly proportional to angle of deflection.

(B) inversely proportional to the angle of deflection.

(C) directly proportional to the square root of the angle of deflection.

(D) inversely proportional to the square root of the angle of deflection.

Ans. Option (A) is correct.

Explanation: In a moving coil galvanometer, current in the coil is directly proportional to angle of deflection.

Q. 16. Current sensitivity of a galvanometer is given by

(A) $C\theta/nBA$ **(B)** nBA/C

(C) nBA/CG **(D)** CG/nBA

Ans. Option (B) is correct.

Explanation: Current sensitivity of a galvanometer is the deflection produced when unit current passes through it.
Current sensitivity = θ/I = nBA/C

Q. 17. The deflecting torque acting on the coil of a galvanometer is

(A) inversely proportional to number of turns.

(B) inversely proportional to current flowing.

(C) inversely proportional to area of the coil.

(D) directly proportional to the magnetic field strength.

Ans. Option (D) is correct.

Explanation: τ = nBIA.
So, torque is directly proportional to the magnetic field strength, area of the coil, number of turns and current flowing.

Q. 18. To convert a galvanometer to ammeter a shunt S is to be connected with the galvanometer. The effective resistance of the ammeter then is

(A) GS/(G+S) **(B)** (G+S)/GS

(C) G+S **(D)** None of the above

Ans. Option (A) is correct.

Explanation: Shunt (S) is connected in parallel to the galvanometer (resistance G). So, the effective resistance is GS/(G+S).

Q. 19. A galvanometer of 100 Ω resistance gives full scale deflection for 10 mA current. To use it as an ammeter of 10 A range, the resistance of the shunt required is

(A) 10 Ω **(B)** 0.10 Ω

(C) 0.01 Ω **(D)** 0.001 Ω

Ans. Option (B) is correct.

Explanation:

$$S = \frac{i_g G}{i - i_g} = \frac{100 \times 0.01}{10 - 0.01} = 0.1\ \Omega$$

Q. 20. An ammeter gives full scale deflection when current of 1.0 A is passed in it. It is converted into a 100 A range ammeter, What will be the ratio of the shunt resistance and its resistance ?

(A) 1 : 9 **(B)** 9 : 1

(C) 1 : 11 **(D)** 11 : 1

Ans. Option (A) is correct.

Explanation: $S = \frac{i_g G}{i - i_g}$

$$S/G = \frac{i_g G}{i - i_g} = \frac{1}{10 - 1} = 1:9$$

Q. 21. A galvanometer can be converted into a voltmeter by connecting a

(A) high resistance in series.

(B) high resistance in parallel.

(C) low resistance in parallel.

(D) low resistance in series.

Ans. Option (A) is correct.

Explanation: To convert a galvanometer into a voltmeter, a high value resistance is to be connected in series with it.

ASSERTION AND REASON BASED MCQs (1 Mark each)

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

Q. 1. Assertion (A): Magnetic field interacts with a moving charge only.

Reason (R): Moving charge produces a magnetic field.

Ans. Option (A) is correct.

Explanation: Current carrying wire creates magnetic field. This magnetic field has no effect on a stationary charge. But when the charge also moves, it creates a current. This current produces a magnetic field. Two fields interact and the charge is deflected. So, the assertion is true. Moving charge creates a current which produces a magnetic field. So, the reason is also true. Reason is the correct explanation of A.

Q. 2. Assertion (A): If an electron is not deflected when moving through a certain region of space, then the only possibility is that no magnetic field is present in that region.

Reason (R): Force on electron is directly proportional to the strength of the magnetic field.

Ans. Option (A) is correct.

Explanation: In absence of magnetic field, moving electron will not be deflected. This possibility is true. So, assertion is true. $\vec{F} = q(\vec{V} \times \vec{B})$. So, force on electron is directly proportional to the strength of the magnetic field. So, reason is true. Reason properly explains the assertion.

Q. 3. Assertion (A): The energy of a charged particle moving in a uniform magnetic field remains constant.

Reasoning (R): Work done by the magnetic field on the charge is zero.

Ans. Option (A) is correct.

Explanation: The force on a charged particle moving in a uniform magnetic field always acts in direction perpendicular to the direction of motion of the charge.

So work done by the magnetic field,

$W = FS \cos\theta = FS \cos 90° = 0$

So, the energy of the charged particle does not change.

Both, assertion and reason are true and reason also explains the assertion.

Q. 4. Assertion (A): An electron and a proton moving with same velocity enters a magnetic field. The force experienced by the proton is more than the force experienced by the electron.

Reason (R): The mass of proton is more than the mass of the electron.

Ans. Option (D) is correct.

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

So, the force is mass independent. So, the assertion is false.

Proton is obviously heavier than electron. So, reason is true. But reason does not explain the assertion.

Q. 5. Assertion (A): The magnetic field at the ends of a very long current carrying solenoid is half of that at the centre.

Reason (R): Magnetic field within a sufficiently long solenoid is uniform.

Ans. Option (B) is correct.

Explanation: Magnetic field inside a solenoid is $B = \mu_0 ni$.
Magnetic field at the end of a solenoid is $\frac{1}{2}\mu_0 ni$.
So, the assertion is true.
Magnetic field within a sufficiently long solenoid is uniform. So reason is also true. But it does not explain the assertion.

Q. 6. Assertion (A): The magnetic field produced by a current carrying solenoid is independent of its length and area of cross-section.

Reason (R): Magnetic field within a very long solenoid is uniform.

Ans. Option (B) is correct.

Explanation: Magnetic field inside solenoid $B = \mu_0 ni$. It is independent of length and area of cross-section. Hence the assertion is true.
Reason is also true. But it does not explain the assertion.

Q. 7. Assertion (A): A direct current flowing through a metallic rod produces magnetic field both inside and outside of the rod.

Reason (R): There is no flow of charge carrier inside the rod.

Ans. Option (C) is correct.

Explanation: Charge carries flows through whole cross-section. So, the filed exists both inside and outside. So, the assertion is true and the reason is false.

Q. 8. Assertion (A): In moving coil galvanometer, the coil is wound on a metallic frame.

Reason (R): The metallic frame helps in making steady deflection without oscillation.

Ans. Option (A) is correct.

Explanation: Coil of a moving coil galvanometer is wound on a metal frame. So, the assertion is true. It is done to avoid any oscillation and fluctuating reading. The metal frame provides damping to reduce the oscillation so that the reading becomes steady. So the reason is also true and properly explains the assertion.

Q. 9. Assertion (A): Torque on a coil is maximum when it is suspended radially in a magnetic field.

Reason (R): Torque tends to rotate a coil .

Ans. Option (B) is correct.

Explanation: The torque on the coil in a magnetic field is given by

$\tau = n$IBA sin θ

For radial field, $\theta = 90°$ and $\sin\theta = 1$

Torque = nIBA and it is maximum.

So assertion is true.

Torque is the rotational equivalence of force. So, torque will tend to rotate a coil.

Reason is also true. But reason cannot explain the assertion that why the torque is maximum in the specified position.

Q. 10. Assertion (A): Galvanometer to ammeter conversion takes place by connecting a low value resistance in parallel with it.

Reason (R): The low value resistance increases the effective resistance and protects the galvanometer.

Ans. Option (C) is correct.

Explanation: Galvanometer to ammeter conversion takes place by connecting a low value resistance known as "shunt" in parallel with it. The assertion is true.

When two resistors are connected in parallel then the effective resistance becomes lower than the lowest value of the two resistors. Hence the reason is false.

Q. 11. Assertion (A): Earth's magnetic field does not affect the functioning of a moving coil galvanometer.

Reason (R): Earth's magnetic field is too weak.

Ans. Option (A) is correct.

Explanation: The coil of moving coil galvanometer is suspended in a very strong radial magnetic field. Earth's magnetic field is too weak compared to that and hence its effect is negligible. So, assertion and reason both are true and the reason explains the assertion properly.

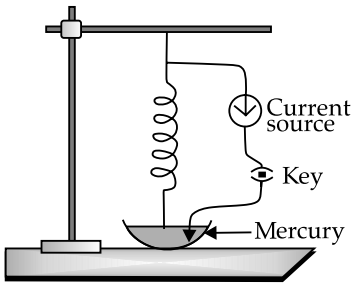
CASE-BASED MCQs

Attempt any 4 sub-parts out of 5. Each sub-part carries 1 mark.

I. Read the following text and answer the following questions on the basis of the same:

Roget's spiral:

Magnetic effects are generally smaller than electric effects. As a consequence, the force between currents is rather small, because of the smallness of the factor μ. Hence, it is difficult to demonstrate attraction or repulsion between currents. Thus, for 5 A current in each wire at a separation of 1 cm, the force per metre would be 5 × 10–4 N, which is about 50 mg weight. It would be like pulling a wire by a string going over a pulley to which a 50 mg weight is attached. The displacement of the wire would be quite unnoticeable. With the use of a soft spring, we can increase the effective length of the parallel current and by using mercury, we can make the displacement of even a few mm observable very dramatically. You will also need a constant-current supply giving a constant current of about 5 A. Take a soft spring whose natural period of oscillations is about 0.5–1 s. Hang it vertically and attach a pointed tip to its lower end, as shown in the figure here. Take some mercury in a dish and adjust the spring such that the tip is just above the mercury surface. Take the DC current source, connect one of its terminals to the upper end of the spring and dip the other terminal in mercury. If the tip of the spring touches mercury, the circuit is completed through mercury. Let the DC source be put off to begin with. Let the tip be adjusted so that it just touches the mercury surface. Switch on the constant current supply and watch the fascinating outcome. The spring shrinks with a jerk, the tip comes out of mercury (just by a mm or so), the circuit is broken, the current stops, the spring relaxes and tries to come back to its original position, the tip again touches mercury establishing a current in the circuit and the cycle continues with tick, tick, tick,...



Q. 1. Magnetic effects:
(A) are equal to electric effects.
(B) are greater than electric effects.
(C) are smaller than electric effects.
(D) cannot be compared with electric effects.

Ans. Option (C) is correct.

> ***Explanation:*** Magnetic effects are generally smaller than electric effects.

Q. 2. The force 10^{-3} N,is equivalent to:
(A) 100 mg **(B)** 100 g
(C) 10 g **(D)** 10 mg

Ans. Option (A) is correct.

> ***Explanation:*** 10^{-3} N = mass in kg × g in m/s^2
> Or, 10^{-3} = mass × 10
> ∴ Mass = 10^{-4} kg = 100 mg

Q. 3. Why the spring shrinks in Roget's spiral ?
(A) The spring functions as a solenoid
(B) Due to force acting between two current carrying wires
(C) Due to magnetic effect of current
(D) Since the spring is soft

Ans. Option (B) is correct.

> ***Explanation:*** The spring shrinks due to force acting between two current carrying wires.

Q. 4. What are the main 3 components in a Roget's spiral?
(A) Mercury, AC voltage source
(b) Mercury, DC voltage source
(C) Mercury, DC voltage source, key
(D) Mercury, AC voltage source, key

Ans. Option (C) is correct.

> ***Explanation:*** Mercury, DC voltage source, key is essential components for the Roget's spiral to work.

Q. 5. What else can be used instead of mercury in Roget's spiral ?
(A) Any liquid
(B) Water
(C) Kerosene oil
(D) Only mercury, nothing else

Ans. Option (D) is correct.

> ***Explanation:*** Only mercury can be used in Roget's spiral since mercury is a liquid metal through which an electrical circuit, may be completed.

II. Read the following text and answer the following questions on the basis of the same:

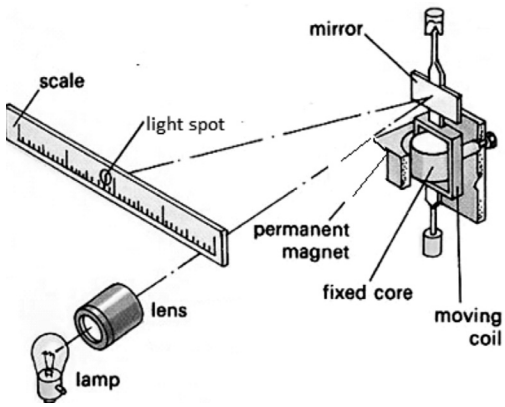
Galvanometer can sense/measure current. Improved mirror galvanometer was developed by William Thomson, later to become Lord Kelvin, in 1858. Thomson intended the instrument to read weak signal currents on very long submarine telegraph cables.

The fundamental problems of transmitting/ receiving a signal through a lengthy submarine cable was that the electrical current tended to be very low (as little as 1/100,000th of a standard light bulb). So, it was very difficult to detect it. To solve the problem it was thought that larger amount of electric current would be sent through the line. But Thomson had a different approach. He thought the best response was to devise a device that could read faint signals. The galvanometer, first invented in 1802, was a means of detecting electric current. It consisted of a needle that was deflected by the magnetic field created by the electric current. But the galvanometers of the day couldn't detect the weak signals that came through a long underwater cable. But the improved version of galvanometer was highly sensitive to detect the lowest current.

The mirror galvanometer consists of a long fine coil of silk-covered copper wire. In the heart of that coil, within a little air-chamber, a small round mirror is hung by a single fibre of floss silk, with four tiny magnets cemented to its back.

A beam of light is thrown from a lamp upon the mirror, and reflected by it upon a white screen or scale a few feet distant, where it forms a bright spot of light; when there is no current on the instrument, the spot of light remains stationary at the zero position on the screen; but the instant a current traverses the long wire of the coil, the suspended magnets twist themselves horizontally out of their former position, the mirror is inclined with them, and the beam of light is deflected along the screen to one side or the other, according to the nature of the current. If a positive electric current gives a deflection to the right of zero, a negative current will give a deflection to the left of zero, and vice versa.

The air in the little chamber surrounding the mirror is compressed, so as to act like a cushion, and deaden the movements of the mirror; the mirror is thus prevented from idly swinging about at each deflections.



Q. 1. Improved mirror galvanometer was developed by
(A) Lord Kelvin
(B) Johann Schweigger
(C) Luigi Galvani
(D) Andre-Marie Ampère

Ans. Option (A) is correct.

> ***Explanation:*** Improved mirror galvanometer was developed by William Thomson, later to become Lord Kelvin, in 1858.

Q. 2. Mirror galvanometer was primarily used to
(A) measure the current passing through electric bulb.
(B) measure the weak current received through lengthy submarine cable.
(C) measure current passing through human body.
(D) all of these.

Ans. Option (B) is correct.

> ***Explanation:*** The fundamental problem was that the transmitting/receiving a signal through a lengthy submarine cable was very low. Instead of increasing the magnitude of the current transmission, Lord Kelvin modified the existing galvanometer so that it became capable to measure the weakest current.

Q. 3. The basic principle of galvanometer is
(A) heating effect of current.
(B) torque developed by the electric current passing through a coil.
(C) magnetic effect of current.
(D) none of the above.

Ans. Option (C) is correct.

> ***Explanation:*** The galvanometer, was a means of detecting electric current. It consisted of a needle that was deflected by the magnetic field created by the electric current.

Q. 4. The mirror galvanometer consists of
(A) a small round mirror attached to a fine coil of silk-covered copper wire.
(B) a long fine coil of silk-covered copper wire and a small round mirror hung by a single fibre of floss silk, with four tiny magnets cemented to its back.

(C) a small round mirror attached to four tiny magnets.

(D) None of the above

Ans. Option (B) is correct.

Explanation: The mirror galvanometer consists of a long fine coil of silk-covered copper wire. In the heart of that coil, within a little air-chamber, a small round mirror is hung by a single fibre of floss silk, with four tiny magnets cemented to its back.

Q. 5. How the idly swinging of the mirror of mirror galvanometer is prevented?

(A) The little chamber surrounding the mirror was filled with a viscous liquid

(B) The mirror was placed in little chamber which was completely vacuum

(C) The mirror was attached to a spring

(D) The little chamber surrounding the mirror was filled with compressed air

Ans. Option (D) is correct.

Explanation: The air in the little chamber surrounding the mirror is compressed, so as to act like a cushion, and deaden the movements of the mirror; the mirror is thus prevented from idly swinging about at each deflections.

III. Read the following text and answer the following questions on the basis of the same:

TOROID

A toroid is a coil of insulated or enamelled wire wound on a donut-shaped form made of powdered iron. A toroid is used as an inductor in electronic circuits, especially at low frequencies where comparatively large inductances are necessary.

A toroid has more inductance , for a given number of turns, than a solenoid with a core of the same material and similar size. This makes it possible to construct high-inductance coils of reasonable physical size and mass. Toroidal coils of a given inductance can carry more current than solenoidal coils of similar size, because larger-diameter wires can be used, and the total amount of wire is less, reducing the resistance .

In a toroid, all the magnetic flux is contained in the core material. This is because the core has no ends from which flux might leak off. The confinement of the flux prevents external magnetic fields from affecting the behaviour of the toroid, and also prevents the magnetic field in the toroid from affecting other components in a circuit.

Standard toroidal transformers typically offer a 95% efficiency, while standard laminated transformers typically offer less than a 90% rating.

One of the most important differences between a toroidal transformer and a traditional laminated transformer is the absence of gaps. The leakage flux through the gaps contributes to the stray losses in the form of eddy currents (which is also expelled in the form of heat).

A toroidal core doesn't have an air gap. The core is tightly wound . The result is a stable, predictable toroidal core, free from discontinuities and holes.

Audible vibration or hum in transformers is caused by vibration of the windings and core layers from the forces between the coil turns and core laminations. The toroidal transformer's construction helps quiet this noise.

In audio, or signal transmitting applications, unwarranted noise will affect sound quality, so a transformer with low audible vibration is ideal. For this reason, many sound system engineers prefer to use a toroidal transformer instead of a traditional laminated transformer.

Q. 1. Toroid is a

(A) fixed value resistor.

(B) capacitor.

(C) inductor.

(D) variable resistor.

Ans. Option (C) is correct.

Explanation: A toroid is a coil of insulated or enamelled wire wound on a donut-shaped form made of powdered iron. A toroid is used as an inductor in electronic circuits.

Q. 2. A toroid has _____ inductance, for a given number of turns, than a solenoid with a core of same material and similar size.

(A) same **(B)** more

(C) less **(D)** variable

Ans. Option (B) is correct.

Explanation: A toroid has more inductance , for a given number of turns, than a solenoid with a core of the same material and similar size. This makes it possible to construct high-inductance coils of reasonable physical size and mass.

Q. 3. Why inductance of solenoid is more than the inductance of a solenoid having same number of turns, core of same material and similar size?

(A) Core is endless hence there no leakage of flux.

(B) Resistance of wire is less hence magnitude of current flow is more

(C) Number of turns per unit length is more.

(D) Both (A) and (B)

Ans. Option (A) is correct.

Explanation: In a toroid, all the magnetic flux is contained in the core material. This is because the core has no ends from which flux might leak off.

Q. 4. Why sound system engineers prefer to use toroidal transformer?

(A) It is cheaper.

(B) It is lighter.

(C) It is compact.

(D) It does not create vibration or hum.

Ans. Option (D) is correct.

> ***Explanation:*** Audible vibration or hum in transformers is caused by vibration of the windings and core layers from the forces between the coil turns and core laminations. The toroidal transformer's construction helps quiet this noise. For this reason, many sound system engineers prefer to use a toroidal transformer instead of a traditional laminated transformer.

Q. 5. Efficiency of toroidal transformer is around _____ % which is _____ than laminated core transformer.

(A) 95, lower **(B)** 95, higher

(C) 50, lower **(D)** 80, higher

Ans. Option (B) is correct.

> ***Explanation:*** Standard toroidal transformers typically offer a 95% efficiency, while standard laminated transformers typically offer less than a 90% rating.

❑❑

CHAPTER

5

Term-I

MAGNETISM AND MATTER

Syllabus

- *Current loop as a magnetic dipole and its magnetic dipole moment, magnetic dipole moment of a revolving electron, bar magnet as an equivalent solenoid, magnetic field lines; earth's magnetic field and magnetic elements.*

STAND ALONE MCQs (1 Mark each)

Q. 1. A toroid of n turns, mean radius R and cross-sectional radius a carries current I. It is placed on a horizontal table taken as x-y plane. Its magnetic moment m

(A) is non-zero and points in the z-direction by symmetry.

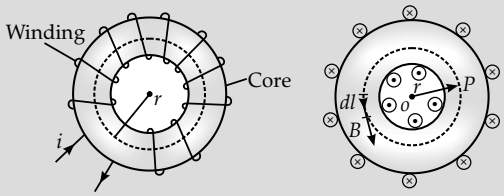
(B) points along the axis of the toroid ($m = m_{\phi}$).

(C) is zero, otherwise there would be a field falling as $\frac{1}{r^3}$ at large distances outside the toroid.

(D) is pointing radially outwards.

Ans. Option (C) is correct.

Explanation: As we know that a toroid can be considered as a ring shaped closed solenoid. So that it is like an endless cylindrical solenoid.



So, the magnetic field is only confined inside the body of a toroid in the form of concentric magnetic lines of force.

For any point inside, the empty space surrounded by toroid and outside the toroid, the magnetic field B is zero because the net current enclosed in these spaces is zero. So that, the magnetic moment of toroid is zero. In general, if we take r as a long distance outside the toroid, the $m \propto \frac{1}{r^3}$ but this case is not possible here.

Q. 2. Consider the two idealized systems : (i) a parallel plate capacitor with large plates and small separation and (ii) a long solenoid of length L, R, radius of cross-section. In (i), E is ideally treated as a constant between plates and zero outside. In (ii), magnetic field is constant inside the solenoid and zero outside. These idealized assumptions, however, contradict fundamental laws as below :

(A) Case (i) contradicts Gauss's law for electrostatic fields.

(B) Case (ii) contradicts Gauss's law for magnetic fields.

(C) Case (i) agrees with $\oint_s \mathrm{E}.dl = 0$

(D) Case (ii) contradicts $\oint \mathrm{H}.dl = \mathrm{I}_{en}$

Ans. Option (B) is correct.

Explanation: According to Gauss's law of electrostatic field,

$$\oint E.ds = \frac{q}{\varepsilon_0}$$

So it does not contradict for electrostatic field as the electric field lines do not form continuous path.

According to Gauss's law of magnetic field, $\oint B.ds = 0$

It is clear that it contradicts for magnetic field because there is magnetic field inside the solenoid, and no field outside the solenoid carrying current, but the magnetic field lines form the closed paths.

Q. 3. A rod of length L, along east-west direction is dropped from a height H. If B be the magnetic field due to Earth at that place and angle of dip is θ, then the magnitude of the induced e.m.f. across two ends of the rod when the rod reachs the Earth is

(A) BLH cos θ **(B)** BL cos θ × $(2gH)^{1/2}$

(C) BL cos θ / $(2gH)^{1/2}$ **(D)** None of the above

Ans. Option (B) is correct.

Explanation: Horizontal component of magnetic field = B cos θ

Velocity of the rod = $(2\ gH)^{1/2}$

Induced e.m.f. = BLv = BL cos θ × $(2\ gH)^{1/2}$

Q. 4. A coil of N turns and radius R carries a current I. It is unwound and rewound to make a square coil of side a having same number of turns (N). Keeping the current I same, the ratio of the magnetic moments of the circular coil and the square coil is

(A) $\pi\frac{R^2}{a^2}$ **(B)** $\pi\frac{a^2}{R^2}$

(C) $\frac{R^2}{a^2}$ **(D)** None of the above

Ans. Option (A) is correct.

Explanation: $\frac{M_{square}}{M_{circular}} = \frac{NIA_{square}}{NIA_{circular}} = \pi R^2 / a^2$

Q. 5. A magnetic dipole moment is a vector quantity directed from:

(A) South to North **(B)** North to South

(C) East to West **(D)** West to East

Ans. Option (A) is correct.

Explanation: Magnetic dipole moment vector is directed from South pole to north pole.

Q. 6. Time period of oscillation of a magnetic needle is

(A) $T = \sqrt{\frac{I}{MB}}$ **(B)** $T = 2\pi\sqrt{\frac{I}{MB}}$

(C) $T = 2\pi\sqrt{\frac{MB}{I}}$ **(D)** $T = \pi\sqrt{\frac{MB}{I}}$

Ans. Option (B) is correct.

Explanation: Time period of oscillation of a magnetic needle is $T = 2\pi\sqrt{\frac{I}{MB}}$

Q. 7. A magnetic needle is kept in a non-uniform magnetic field experiences

(A) a force as well as a torque

(B) a torque but not a force

(C) a force and a torque

(D) a force but not a torque

Ans. Option (A) is correct.

Explanation: Field being non-uniform, the poles of the needle will experience non-uniform forces. Hence, the needle experiences a force as well as a torque.

Q. 8. The magnetic field of Earth can be modelled by that of a point dipole placed at the centre of the Earth. The dipole axis makes an angle of 11.3° with the axis of Earth. At Mumbai, declination is nearly zero. Then,

(A) the declination varies between 11.3° W to 11.3° E.

(B) the least declination is 0°.

(C) the plane defined by dipole axis and Earth axis passes through Greenwich.

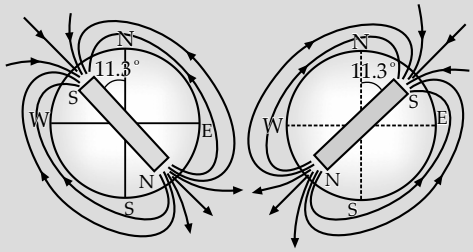
(D) declination averaged over Earth must be always negative.

Ans. Option (A) is correct.

Explanation: The magnetic field lines of the Earth resemble that of a hypothetical magnetic dipole located at the centre of the Earth.

The axis of the dipole does not coincide with the axis of rotation of the Earth and it is tilted at some angle (angle of declination).

In this situation, the angle of declination is approximately 11.3° with respect to the later. So, there is two possibilities arises as shown :



So that the declination varies between 11.3° W to 11.3° E.

Q. 9. Let the magnetic field on Earth be modelled by that of a point magnetic dipole at the centre of Earth. The angle of dip at a point on the geographical equator

(A) is always zero.
(B) is always positive
(C) is always negative
(D) can be positive or negative or zero.

Ans. Option (D) is correct.

Explanation: Angle of inclination or dip is the angle between the direction of intensity of total magnetic field of the Earth and a horizontal line in the magnetic meridian.
If the total magnetic field of the Earth is modelled by a point magnetic dipole at the centre, then it is in the same plane of geographical equator, thus the angle of dip on the geographical equator will be different at different points. It may be positive or negative or may be zero at some points.

Q. 10. Relative permeability of a magnetic material is 0.5. The material is
(A) diamagnetic.
(B) ferromagnetic.
(C) paramagnetic.
(D) not a magnetic material.

Ans. Option (A) is correct.

Explanation: Relative permeability of diamagnetic magnetic material is less than 1.

Q. 11. Which of the following relation is correct?
(A) $B = B_V \times B_H$ **(B)** $B = B_V / B_H$
(C) $B = B_V + B_H$ **(D)** $B = \sqrt{B_V^2 + B_H^2}$

Ans. Option (D) is correct.

Explanation: $B_H = B \cos\theta$
$B_V = B \sin\delta$
$\therefore \quad B = \sqrt{B_V^2 + B_H^2}$

Q. 12. Ratio of total intensity of magnetic field at equator to poles is
(A) 1:1 **(B)** 1:2
(C) 2:1 **(D)** None of the above

Ans. Option (A) is correct.

Explanation: $B_H = B \cos\theta$
$B_V = B \sin\delta$
At equator, $\delta = 0°$.
So, $B_H = B$, $B_V = 90°$
At poles, $\delta = 90°$.
So, $B_H = B$, $B_V = B$
So, the ratio of total intensity of magnetic field at equator to poles is 1 : 1.

Q. 13. Which of the following is most suitable for the core of an electromagnet?
(A) Soft iron **(B)** Steel
(C) Alnico **(D)** Copper

Ans. Option (A) is correct.

Explanation: Soft Iron gets magnetized faster but loses its magnetism as soon as the current stops flowing in solenoid. Hence soft iron is said to have high susceptibility but low retentivity. This property of soft iron makes it suitable for core of electromagnets where we need strong but temporary magnetism as long as current is flowing.

Q. 14. A ferromagnetic substance is heated above its curie temperature. Which of the following statements is correct?
(A) Ferromagnetic domains get perfectly arranged.
(B) Ferromagnetic domains get randomly arranged.
(C) Ferromagnetic domains are not at all influenced.
(D) Ferromagnetic material transforms into diamagnetic substance.

Ans. Option (B) is correct.

Explanation: On heating above Curie temperature, Ferromagnetic domains get randomly arranged and it transforms into paramagnetic substance.

ASSERTION AND REASON BASED MCQs (1 Mark each)

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

Q. 1. Assertion (A): The magnetic field configuration with 3 poles is not possible.
Reason (R): No torque acts on a bar magnet itself due to its own field.

Ans. Option (B) is correct.

Explanation: Magnetic poles exist in pairs. So assertion is true.
The bar magnet does not exert a torque on itself in its own magnetic field. Torque is proportional to cross product of $\vec{M}$ and $\vec{B}$. The angle between $\vec{M}$ and $\vec{B}$ being 0, the cross product is 0. So, there will be no torque. So reason is also true.
But R cannot explain A.

Q. 2. Assertion (A): Magnetic poles cannot be separated by breaking a bar magnet into two pieces.

Reason (R): When a magnet is broken into two pieces, the magnetic moment will be reduced to half.

Ans. Option (B) is correct.

Explanation: Magnetic poles always exist in pairs even in atomic level. So assertion is true.
When a magnet is broken into two pieces, the pole strength remains same; only the length becomes half. So, the magnetic moment becomes half. So, the reason is also true.
But R is not the proper explanation of A.

Q. 3. Assertion (A): The basic difference between magnetic lines of force and electric lines of force is electric lines of force are discontinuous and magnetic lines of force are continuous.

Reason (R): Magnetic lines of force exist in a magnet but no electric lines of force exist in a charged body.

Ans. Option (A) is correct.

Explanation: Let us consider an electric dipole. The electric lines of force exist outside only and not inside the dipole.

Let us take a magnetic dipole. The magnetic lines of force exist outside as well as inside the dipole.

So, it can be said that magnetic lines of force are continuous and electric lines of force are discontinuous.

So assertion and reason both are true and reason explains the assertion too.

Q. 4. Assertion (A): Gauss theorem is not applicable in magnetism.

Reason (R): Magnetic monopole does not exist.

Ans. Option (A) is correct.

Explanation: Gauss's theorem of magnetism is different from that for electrostatics because electric charges may not exist in pair but magnetic poles always exist in pair. So assertion is true.
Magnetic monopole does not exist. Magnetic poles always exist in pair. So reason is also true and reason clearly explains the assertion.

Q. 5. Assertion (A): A compass needle when placed at Earth's magnetic pole rotates in vertical plane.

Reason (R): The Earth has only horizontal component of its magnetic field at the poles.

Ans. Option (D) is correct.

Explanation: Magnetic needle can rotate in horizontal plane only. But at poles, there is no horizontal component of Earth's magnetic field.
So, the needle will remain horizontal and will point in any direction. Hence the assertion is false.
At poles, Earth has only vertical components of its magnetic field. Hence, the reason is also false.

Q. 6. Assertion (A): Compass needle points the magnetic north-south direction.

Reason (R): The magnetic meridian of the earth merges with the axis of rotation of earth.

Ans. Option (D) is correct.

Explanation: Compass needle points the magnetic north-south direction. So the assertion is true.
Earth's magnetic meridian is along its axis through magnetic north-south direction. Earth's axis of rotation is along its geographic north-south direction. The angle between these two axes is 11.3°. Hence, the reason is also false.

Q. 7. Assertion (A): Ferromagnetic substances become paramagnetic beyond Curie temperature.

Reason (R): Domains are destroyed at high temperature.

Ans. Option (A) is correct.

Explanation: From Curie Weiss law,

$$\chi = \frac{C}{T - T_C}$$

As temperature increases beyond Curie temperature, susceptibility decreases and the ferromagnetic substances become paramagnetic. So, the assertion is true.
Paramagnetic substance has no magnetic domain. At a very high temperature, the domains of ferromagnetic substance get destroyed and the substance transforms into paramagnetic substance. So, the reason is also true and properly explains the assertion.

Q. 8. Assertion (A): Gauss's law of magnetism is different from Gauss's law of electrostatics.

Reason (R): Isolated electric charge can exist but isolated magnetic pole cannot exist.

Ans. Option (A) is correct.

Explanation: In electrostatics, Gauss's law:

$$= \int \vec{E}.d\vec{A} = \frac{q}{\varepsilon_0}$$

Gauss's law of magnetism:

$$\int \vec{B}.d\vec{A} = 0$$

Gauss's law of magnetism is different from Gauss's law of electrostatics. Hence, the assertion is true.
Electric charge may or may not exist in pair. But magnetic poles always exist in pair.

No magnetic monopole exists. This is the reason why Gauss's law of magnetism is different from Gauss's law of electrostatics. So, the reason is also true and explains the assertion.

CASE-BASED MCQs

Attempt any 4 sub-parts out of 5. Each sub-part carries 1 mark.

I. Read the following text and answer the following questions on the basis of the same:

Earth's magnetism: Earth's magnetic field is caused by a dynamo effect. The effect works in the same way as a dynamo light on a bicycle. Magnets in the dynamo start spinning when the bicycle is pedaled, creating an electric current. The electricity is then used to turn on the light. This process also works in reverse. If you have a rotating electric current, it will create a magnetic field. On Earth, flowing of liquid metal in the outer core of the planet generates electric currents. The rotation of Earth on its axis causes these electric currents to form a magnetic field which extends around the planet. The average magnetic field strength in the Earth's outer core was measured to be 25 Gauss, 50 times stronger than the magnetic field at the surface. The magnetic field is extremely important for sustaining life on Earth. Without it, we would be exposed to high amounts of radiation from the Sun and our atmosphere would be free to leak into space. This is likely what happened to the atmosphere on Mars. As Mars doesn't have flowing liquid metal in its core, it doesn't produce the same dynamo effect. This left the planet with a very weak magnetic field, allowing for its atmosphere to be stripped away by solar winds, leaving it uninhabitable. Based upon the study of lava flows throughout the world, it has been proposed that the Earth's magnetic field reverses at an average interval of approximately 300,000 years. However, the last such event occurred some 780,000 years ago.

Q. 1. Which of the followings is the reason for Earth's magnetism ?

(A) Rotation of electric current

(B) Rotation of Earth

(C) Attraction due to other celestial bodies

(D) Solar flares

Ans. Option (A) is correct.

Explanation: On Earth, flowing of liquid metal in the outer core of the planet generates electric currents. The rotation of Earth on its axis causes these electric currents to form a magnetic field which extends around the planet.

Q. 2. Electric current in the Earth's body is generated due to:

(A) movement of charged particle in the atmosphere.

(B) flowing of liquid metal in the outer core.

(C) electric discharges during thunderstorm.

(D) its revolution round the Sun.

Ans. Option (A) is correct.

Explanation: On Earth, flowing of liquid metal in the outer core of the planet generates electric currents.

Q. 3. Which planet has no own magnetic field ?

(A) Jupiter **(B)** Neptune

(C) Mars **(D)** Mercury

Ans. Option (C) is correct.

Explanation: As Mars doesn't have flowing liquid metal in its core, it doesn't produce dynamo effect. So, it has very weak or almost no magnetic field.

Q. 4. Average magnetic field strength in the Earth's outer core is:

(A) 5 Gauss **(B)** 25 Gauss

(C) 500 Gauss **(D)** Cannot be measured

Ans. Option (B) is correct.

Explanation: The average magnetic field strength in the Earth's outer core was measured to be 25 Gauss.

Q. 5. Which of the following statements is true ?

(A) Earth's magnetic field is due to electric current induced in the ionosphere.

(B) The average magnetic field strength in the Earth's outer core is equal to the magnetic field at the surface.

(C) Earth's magnetic field reverses at an average interval of approximately 3,00,000 years.

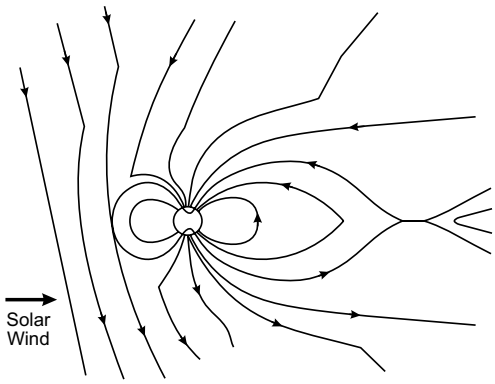
(D) Angle of dip is same at every point of the surface of Earth.

Ans. Option (C) is correct.

> ***Explanation:*** Based upon the study of lava flows throughout the world, it has been proposed that the Earth's magnetic field reverses at an average interval of approximately 300,000 years.

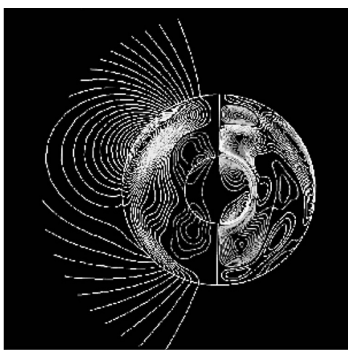
II. Read the following text and answer the following questions on the basis of the same:

If we move into space and study the Earth's invisible magnetic field, it wouldn't really look like a bar magnet at all. Earth's magnetic field gets stretched out into a comet-like shape with a tail of magnetism that stretches millions of miles behind the earth, opposite to the Sun. The Sun has a wind of gas that pushes the earths field from the left to the right in the picture.



The core of the Earth is an electromagnet. Although the crust is solid, the core of the Earth is surrounded by a mixture of molten iron and nickle. The magnetic field of Earth is caused by currents of electricity that flow in the molten core. These currents are hundreds of miles wide and flow at thousands of miles per hour as the Earth rotates. The powerful magnetic field passes out through the core of the Earth, passes through the crust and enters space. This picture shows the solid inner core region (inner circle) surrounded by a molten outer core (the area between the two circles). The currents flow in the outer core, travel outwards through the rest of the earth's interior.

If the Earth rotated faster, it would have a stronger magnetic field.



By the time the field has reached the surface of Earth, it has weakened a lot, but it is still strong enough to keep your compass needles pointed towards one of its poles. All magnets have two poles: a North Pole and a South Pole. The magnetic poles of earth are not fixed on the surface, but wander quite a bit. The pole in the Northern Hemisphere seems to be moving northwards in geographic latitude by about 10 kilometres per year by an average.

Q. 1. Earth's magnetic field has a:
- **(A)** shape of the magnetic field of a bar magnet.
- **(B)** shape of the magnetic field of a horseshoe magnet.
- **(C)** shape of a sphere.
- **(D)** None of the above

Ans. Option (D) is correct.

> ***Explanation:*** Earth's magnetic field gets stretched out into a comet-like shape with a tail of magnetism that stretches millions of miles behind the Earth, opposite from the Sun.

Q. 2. Core of the Earth is:
- **(A)** an electromagnet. **(B)** a permanent magnet.
- **(C)** a unipolar magnet. **(D)** None of these

Ans. Option (A) is correct.

> ***Explanation:*** The core of the Earth is an electromagnet. Although the crust is solid, the core of the Earth is surrounded by a mixture of molten iron and nickle. The magnetic field of Earth is caused by currents of electricity that flow in the molten core.

Q. 3. The magnetic poles of Earth are:
- **(A)** fixed on the surface
- **(B)** wander throughout the Earth's surface
- **(C)** wander about 1000 kilometres per year on an average.
- **(D)** wander about 10 kilometres per year on an average.

Ans. Option (D) is correct.

> ***Explanation:*** The magnetic poles of Earth are not fixed on the surface, but wander quite a bit. The pole in the Northern Hemisphere seems to be moving northwards in geographic latitude by about 10 kms per year on an average.

Q. 4. Earth's magnetic field may increase if:
- **(A)** it rotates on its axis faster.
- **(B)** its direction of rotation is changed.
- **(C)** it revolves round the Sun faster.
- **(D)** All of the above

Ans. Option (A) is correct.

> ***Explanation:*** If the Earth rotated faster, it would have a stronger magnetic field.

Q. 5. The Earth's magnetism is due to:
- **(A)** induction of Sun's magnetism.
- **(B)** current produced by the movement of molten metals.

(C) sea current.

(D) revolution of the Earth round the Sun.

Ans. Option (B) is correct.

> ***Explanation:*** The Earth crust is solid, the core of the Earth is surrounded by a mixture of molten iron and nickle. The magnetic field of Earth is caused by currents of electricity that flow in the molten core. These currents are hundreds of miles wide and flow at thousands of miles per hour as the Earth rotates.

III. Read the following text and answer the following questions on the basis of the same:

Super magnet

The term super magnet is a broad term and encompasses several families of rare-earth magnets that include seventeen elements in the periodic table; namely scandium, yttrium, and the fifteen lanthanides. These elements can be magnetized, but have Curie temperatures below room temperature. This means that in their pure form, their magnetism only appears at low temperatures. However, when they form compounds with transition metals such as iron, nickel, cobalt, etc. Curie temperature rises well above room temperature and they can be used effectively at higher temperatures as well. The main advantage they have over conventional magnets is that their greater strength allows for smaller, lighter magnets to be used.

Super magnets are of two categories:

(i) *Neodymium magnet:* These are made from an alloy of neodymium, iron, and boron. This material is currently the strongest known type of permanent magnet. It is typically used in the construction of head actuators in computer hard drives and has many electronic applications, such as electric motors, appliances, and magnetic resonance imaging (MRI).

(ii) *Samarium-cobalt magnet*: These are made from an alloy of samarium and cobalt. This second-strongest type of rare Earth magnet is also used in electronic motors, turbo-machinery, and because of its high temperature range tolerance may also have many applications for space travel, such as cryogenics and heat resistant machinery.

Rare-earth magnets are extremely brittle and also vulnerable to corrosion, so they are usually plated or coated to protect them from breaking, chipping, or crumbling into powder.

Since super magnets are about 10 times stronger than ordinary magnets, safe distance should be maintained otherwise these may damage mechanical watch, CRT monitor, pacemaker, credit cards, magnetically stored media etc.

These types of magnets are hazardous for health also. The greater force exerted by rare-earth magnets creates hazards that are not seen with other types of magnet. Magnets larger than a few centimeters are strong enough to cause injuries to body parts pinched between two magnets or a magnet and a metal surface, even causing broken bones.

Neodymium permanent magnets lose their magnetism 5% every 100 years. So, in the truest sense Neodymium magnets may be considered as a permanent magnet.

Q. 1. Curie point of pure rare Earth elements is

(A) very high.

(B) below room temperature.

(C) 0 K.

(D) varies from element to element.

Ans. Option (B) is correct.

> ***Explanation:*** Rare-Earth elements which can be magnetized have Curie temperatures below room temperature. This means that in their pure form, their magnetism only appears at low temperatures.

Q. 2. Neodymium and Samarium are

(A) diamagnetic.

(B) paramagnetic.

(C) ferromagnetic.

(D) not magnetic materials.

Ans. Option (C) is correct.

Q. 3. Super magnets are about _____ time stronger than ordinary magnets.

(A) 10 **(B)** 100

(C) 1000 **(D)** 10000

Ans. Option (A) is correct.

Q. 4. To raise the Curie point of rare Earth elements.

(A) they are coated with gold.

(B) compounds are formed with transition metals.

(C) they are oxidized.

(D) None of the above

Ans. Option (B) is correct.

> ***Explanation:*** When rare-Earth elements form compounds with transition metals such as iron, nickel, cobalt, etc. Curie temperatures thus rise well above room temperature.

Q. 5. Neodymium permanent magnets lose their magnetism ____ % every 100 years.

(A) 50 **(B)** 0.5

(C) 10 **(D)** None of the above

Ans. Option (B) is correct.

> ***Explanation:*** Neodymium permanent magnets lose their magnetism 5% every 100 years. So, in the truest sense. Neodymium magnets may be considered as a permanent magnet.

❐❐

PART – IV : ELECTROMAGNETIC INDUCTION AND ALTERNATING CURRENTS

CHAPTER 6

Term-I

ELECTROMAGNETIC INDUCTION

Syllabus

- *Electromagnetic induction; Faraday's laws, induced emf and current; Lenz's Law.*
- *Eddy currents, Self and mutual induction.*

STAND ALONE MCQs (1 Mark each)

Q. 1. A square of side L meters lies in the *x-y* plane in a region where the magnetic field is given by $\mathbf{B} = B_0(2\hat{i} + 3\hat{j} + 4\hat{k})$ Tesla, where B_0 is constant. The magnitude of flux passing through the square is

(A) $2B_0L^2$ Wb **(B)** $3B_0L^2$ Wb

(C) $4B_0L^2$ Wb **(D)** $\sqrt{29}B_0L^2$ Wb

Ans. Option (C) is correct.

Explanation: 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.

Square lies in X-Y plane in $\vec{B}$ so $\vec{A} = L^2\hat{k}$

$$Q = B.A$$
$$= B_0(2\hat{i} + 3\hat{j} + 4\hat{k}).(L^2\hat{k})$$
$$= B_0[2\times\hat{i}\hat{k} + 3\times\hat{j}\hat{k} + 4\times\hat{k}.\hat{k}]$$
$$= B_0L^2[0 + 0 + 4]$$
$$= 4B_0L^2 Wb.$$

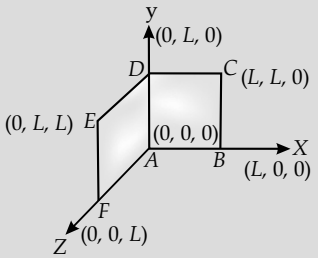
Q. 2. A loop, made of straight edges has six corners at A(0, 0, 0), B(L, 0, 0) C(L, L, 0), D(0, L, 0), E(0, L, L) and F(0, 0, L). A magnetic field $B = B_0(\hat{i} + \hat{k})$ Tesla is present in the region. The flux passing through the loop ABCDEFA (in that order) is

(A) B_0L^2 Wb. **(B)** $2B_0L^2$ Wb.

(C) $\sqrt{2}B_0L^2$ Wb . **(D)** $4B_0L^2$ Wb.

Ans. Option (B) is correct.

Explanation: The loop can be considered in two planes :



(i) Plane of ABCDA is in X-Y plane. So its vector $\vec{A}$ is in Z-direction. Hence,

$$A_1 = |A|\hat{k} = L^2\hat{k}$$

(ii) Plane of DEFAD is in Y-Z plane

So $A_2 = |A|\hat{i} = L^2\hat{i}$

$\therefore \quad A = A_1 + A_2 = L^2(\hat{i} + \hat{k})$

$B = B_0(\hat{i} + \hat{k})$

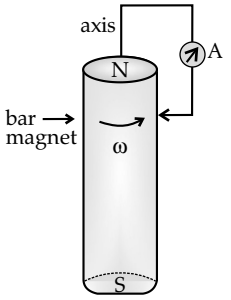
So, $Q = B.A = B_0(\hat{i} + \hat{k}).L^2(\hat{i} + \hat{k}) = B_0L^2$

$[\hat{i}.\hat{i} + \hat{i}.\hat{k} + \hat{k}.\hat{i} + \hat{k}.\hat{k}]$

$= B_0L^2[1 + 0 + 0 + 1] \quad (\therefore \cos 90° = 0)$

$= 2B_0L^2 Wb$

Q. 3. 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

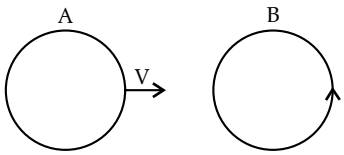


(A) a direct current flows in the ammeter A.
(B) no current flows through the ammeter A.
(C) an alternating sinusoidal current flows through the ammeter A with a time period $2\pi/\omega$.
(D) a time varying non-sinusoidal current flows through the ammeter A.

Ans. Option (B) is correct.

> ***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.

Q. 4. 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

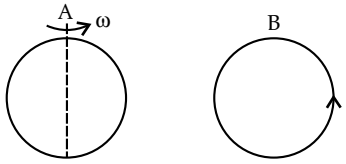


(A) there is a constant current in the clockwise direction in A.
(B) there is a varying current in A.
(C) there is no current in A.
(D) there is a constant current in the counter clockwise direction in A.

Ans. Option (D) is correct.

> ***Explanation:*** 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.

Q. 5. 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.

Ans. Option (A) is correct.

> ***Explanation:*** 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 counter-clockwise 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.

Q. 6. The polarity of induced emf is defined by
(A) Ampere's circuital law.
(B) Biot-Savart law.
(C) Lenz's law.
(D) Fleming's right hand rule.

Ans. Option (C) is correct.

> ***Explanation:*** 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.

Q. 7. Lenz's law is consequence of the law of conservation of
(A) Charge **(B)** mass
(C) energy **(D)** momentum

Ans. Option (C) is correct.

> ***Explanation:*** Lenz's law is a consequence of the law of conservation of energy.
> Lenz 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 a consequence of law of conservation of energy.

Q. 8. The magnetic flux linked with a coil is given by an equation $\phi = 5t^2 + 2t + 3$.

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

Ans. Option (A) is correct.

Explanation: Induced e.m.f $= -d\phi/dt$
$= (5t^2 + 2t + 3) = -(10t + 2) = -32$

Q. 9. 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.

Ans. Option (B) is correct.

Explanation: As we know that,

$$L = \mu_r \mu_0 \frac{N^2 A}{l}$$

As L is constant for a coil,

$L \propto A$ and $L \propto -$

As μ_r and N are constant here so, to increase L for a coil, area A must be increased and l must be decreased. So answer (B) is correct.

Important point : The self and mutual inductance of capacitance and resistance depend on the geometry of the devices as well as permittivity/permeability of the medium.

Q. 10. An iron-cored solenoid has self inductance 2.8H. When the core is removed, the self inductance becomes 2 mH. The relative permeability of the material of the core is

(A) 1400 **(B)** 1200

(C) 2800 **(D)** 2000

Ans. Option (A) is correct.

Explanation: $\mu_r = L/L_0 = 2.8/(2 \times 10^{-3}) = 1400$

Q. 11. In which of the following application, eddy current has no role to play?

(A) Electric power meters

(B) Induction furnace

(C) LED lights

(D) Magnetic brakes in trains

Ans. Option (C) is correct.

Explanation: LED is a *p-n* junction diode and emits light when forward biased.

Q. 12. Which one of the following statements is wrong?

(A) Eddy currents are produced in a steady magnetic field.

(B) Eddy current is used to produce braking force in moving trains.

(C) Eddy currents is minimized by using laminated core.

(D) Induction furnace uses eddy current to produce heat

Ans. Option (A) is correct.

Explanation: Eddy current is produced when a metal is kept in a time varying magnetic field.

Q. 12. 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

Ans. Option (C) is correct.

Explanation: $e = -L \dfrac{di}{dt}$

$$5 = -L \times \frac{0-1}{10^{-3}}$$

$$\therefore \quad L = 5 \times 10^{-3} \text{ H}$$

Q. 13. Magnetic field energy stored in a coil is

(A) Li^2 **(B)** ½ Li

(C) Li **(D)** ½ Li^2

Ans. Option (D) is correct.

Explanation: If current I flows through a coil of self-inductance L, then magnetic field energy stored in it is ½ Li^2

Q. 14. If two coils of self inductance L_1 and L_2 are coupled together, their mutual inductance becomes

(A) $M = k\sqrt{L_1 L_2}$ **(B)** $M = k\sqrt{\dfrac{L_1}{L_2}}$

(C) $M = k\sqrt{L_1 + L_2}$ **(D)** None of the above

Ans. Option (A) is correct.

Explanation: If two coils of self inductance L_1 and L_2 are coupled together, their mutual inductance becomes $M = k\sqrt{L_1 L_2}$ where k = coupling constant whose value lies between 0 and 1.

Q. 15. 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.

Ans. Option (B) is correct.

Explanation: 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 AND REASON BASED MCQs (1 Mark each)

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

Q. 1. Assertion(A): Faraday's laws of electromagnetic induction are consequences of law of conservation of energy.
Reason (R): The parameter LR in a L-R circuit has the dimension of time.

Ans. Option (C) is correct.

> ***Explanation:*** In electromagnetic induction, magnetic energy, mechanical energy are converted into electrical energy. So, Faraday's laws of electromagnetic induction are direct consequences of law of conservation of energy. Hence assertion is true.
> In a L-R circuit, L/R parameter has the dimension of time. Hence the reason is false.

Q. 2. Assertion (A): When two identical loops of copper and Aluminium are rotated with same speed in the same magnetic field, the induced e.m.f. will be same.
Reason (R): Resistance of the two loops are equal.

Ans. Option (C) is correct.

> ***Explanation:*** Induced e.m.f. in a rotating loop in a magnetic field depends on the area of the loop, number of turns, speed of rotation and magnetic field strength. It does not depend on the material of the coil. So, when two identical loops of copper and aluminium are rotated with same speed in the same magnetic field, the induced e.m.f. will be same. So, the assertion is true.
> Resistance of the two loops cannot be equal. Resistance of copper loop is less than that of the aluminium loop. So, the reason is false.

Q. 3. Assertion (A): Lenz's law does not violets the principle of conservation of energy.
Reason (R): Induce e.m.f. never opposes the change in magnetic flux that causes the e.m.f.

Ans. Option (C) is correct.

> ***Explanation:*** Lenz's law is based on principle of conservation of energy. So, the assertion is true.
> Induced e.m.f. always opposes the change in magnetic flux that causes the e.m.f. So, the reason is also false.

Q. 4. Assertion (A): If the number of turns of a coil is increased, it becomes more difficult to push a bar magnet towards the coil.
Reason (R): The difficulty faced is according to Lenz's law.

Ans. Option (A) is correct.

> ***Explanation:*** As it is tried to push a bar magnet towards a coil, magnetic flux increases. According to Faraday's law induced e.m.f. is generated. As the number of turns increases, induced e.m.f. increases.
> According to Lenz's law, Induced e.m.f. always opposes the change in magnetic flux that causes the induction of e.m.f. So, the induced e.m.f. will oppose the motion of the bar magnet towards the coil. As the number of turns increases, opposition increases. Hence both assertion and reason are true and the reason explains the assertion properly.

Q. 5. Assertion (A): When the magnetic flux changes around a metallic conductor, the eddy current is produced.
Reason (R): Electric potential determines the flow of charge.

Ans. Option (B) is correct.

> ***Explanation:*** Change in flux induces emf in conductor which generates eddy current. So assertion is true.
> Electric potential determines the flow of charge. So reason is also true. But reason is not the proper explanation of generation of eddy current.

Q. 6. Assertion (A): The cores of electromagnets are made of soft iron.
Reason (R): Coercivity of soft iron is small.

Ans. Option (A) is correct.

> ***Explanation:*** The core of an electromagnet should be such that it gets magnetized easily. Also, it loses magnetism easily as soon as the magnetizing field is removed. Soft iron has this property. So, soft iron is used as the core electromagnet. So the assertion is true. Coercivity is a measure of the ability of a ferromagnetic substance to withstand external magnetic field without becoming demagnetized. For soft iron, it should be very low. Coercivity is low for soft iron. So, reason is also true. Also, reason properly explains the assertion.

Q. 7. Assertion (A): Mutual inductance becomes maximum when coils are wound on each other.
Reason (R): Mutual inductance is independent of orientation of coils.

Ans. Option (C) is correct.

> ***Explanation:*** Mutual inductance depends on size, number of turns, relative position and relative orientation of the 2 coils. So, when coils are wound on each other, the mutual inductance will be maximum.
> So, assertion is true, But the reason is false.

Q. 8. Assertion (A): Self inductance may be called the inertia of electricity.
Reason (R): Due to self inductance, opposing induced e.m.f. is generated in a coil as a result of change in current or magnetic flux linked with the coil.

Ans. Option (B) is correct.

> ***Explanation:*** Inertia is defined as the tendency of an object to resists its change of state of motion. Induced e.m.f. in a coil is changed by the change in current or magnetic flux. The property by which a coil opposes these parameters to incur any change in induced e.m.f. is known as self-inductance. Hence, self inductance may be called the inertia of electricity. So, the assertion and reason both are true but reason cannot explain why so happens.

CASE-BASED MCQs

Attempt any 4 sub-parts out of 5. Each sub-part carries 1 mark.

I. Read the following text and answer the following questions on the basis of the same:

Bottle Dynamo: A bottle dynamo is a small generator to generate electricity to power the bicycle light.

Is is not a dynamo. 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.

Q. 1. 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

Ans. Option (A) is correct.

> ***Explanation:*** Dynamo generates DC. But bottle dynamo generates AC. So, it is not a dynamo in that sense. But, it generates electricity for bicycle light.

Q. 2. 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

Ans. Option (C) is correct.

> ***Explanation:*** 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.

Q. 3. 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.

Ans. Option (B) is correct.

> ***Explanation:*** 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.

Q.4. 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.

Ans. Option (C) is correct.

> ***Explanation:*** Normal lamps work with both AC and DC. So, bottle generators of older model or newer model can be directly used for bicycle lamp.

Q. 5. 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

Ans. Option (A) is correct.

> ***Explanation:*** 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.

II. Read the following text and answer the following questions on the basis of the same:

Electromagnetic damping: Take two hollow thin cylindrical pipes of equal internal diameters made of aluminium and *PVC*, respectively. Fix them vertically with clamps on retort stands. Take a small cylindrical magnet having diameter slightly smaller than the inner diameter of the pipes and drop it through each pipe in such a way that the magnet does not touch the sides of the pipes during its fall.

You will observe that the magnet dropped through the *PVC* pipe takes the same time to come out of the pipe as it would take when dropped through the same height without the pipe.

Now instead of *PVC* pipe use an aluminium pipe. Note the time it takes to come out of the pipe in each case. You will see that the magnet takes much longer time in the case of aluminium pipe.

Why is it so ? It is due to the eddy currents that are generated in the aluminium pipe which oppose the change in magnetic flux, *i.e.*, the motion of the magnet. The retarding force due to the eddy currents inhibits the motion of the magnet. Such phenomena are referred to as electromagnetic damping.

Note that eddy currents are not generated in PVC pipe as its material is an insulator whereas aluminium is a conductor.

This effect was discovered by physicist Foucault (1819-1868).

Q. 1. Eddy current is generated in a:

(A) metallic pipe. **(B)** PVC pipe.

(C) glass pipe. **(D)** wooden pipe.

Ans. Option (A) is correct.

> ***Explanation:*** Eddy currents are not generated in non-conductor/insulator. Eddy currents are generated in conductor/metal.

Q. 2. Eddy current was first observed by:

(A) Helmhotlz **(B)** Foucault

(C) D'Arsonval **(D)** Shock ley

Ans. Option (B) is correct.

> ***Explanation:*** The generation of eddy current was discovered by physicist Foucault (1819-1869).

Q. 3. What is electromagnetic damping ?

(A) Generation of electromagnetic wave during the passage of a magnet through a metal pipe

(B) Change of the direction of propagation of electromagnetic wave due to a variable magnetic flux

(C) Change of the frequency of electromagnetic wave due to a variable magnetic flux

(D) To slow down the motion of a magnet moving through a metal pipe due to electromagnetically induced current.

Ans. Option (D) is correct.

> ***Explanation:*** The retarding force due to the eddy currents inhibits the motion of the magnet in a metal pipe. This phenomena is known as electromagnetic damping.

Q. 4. To observe electromagnetic damping a magnet should be dropped through a metal pipe and:

(A) the magnet should not touch inner wall of the pipe.

(B) the magnet should touch the inner wall of the pipe.

(C) it does not matter whether the magnet touches the inner wall of the pipe or not.

(D) the magnet should be larger in size than the diameter of the pipe.

Ans. Option (A) is correct.

> ***Explanation:*** To observe electromagnetic damping, a magnet should be dropped through a metal pipe and the magnet should not touch the inner wall of the pipe.

Q. 5. A piece of wood and a bar magnet of same dimension is dropped through an aluminium pipe. Which of the following statements is true ?

(A) The piece of wood will take more time to come out from the pipe.

(B) The bar magnet will take more time to come out from the pipe.

(C) Both will take same time to come out from the pipe.

(D) The time required will depend on the mass of the wooden piece and the mass of the bar magnet.

Ans. Option (B) is correct.

> ***Explanation:*** When a piece of wood and a bar magnet of same dimension is dropped through an aluminium pipe, the bar magnet will take more time to come out from the pipe due to electromagnetic damping.

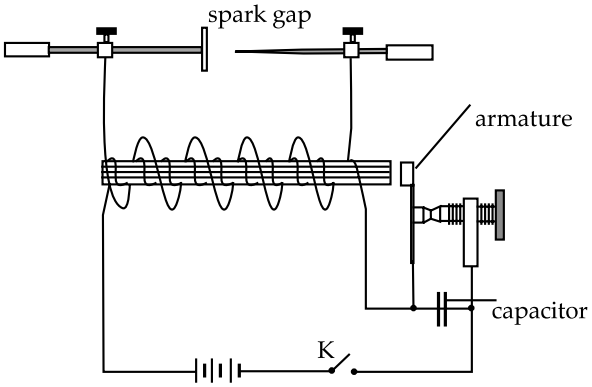
III. Read the following text and answer the following questions on the basis of the same:

Spark coil

The principle of electromagnetic induction was discovered by Michael Faraday in 1831. Induction coils were used widely in electrical experiments and for medical therapy during the last half of the 19th century, eventually leading to the development of radio in the 1890's.

The spark coil designed on the principle of electromagnetic induction was the heart of the earliest radio transmitters. Marconi used a spark coil designed by Heinrich Rhumkorff in his early experiments.

An **induction coil** or "spark coil" is a type of electrical transformer used to produce high-voltage pulses from a low-voltage (DC) supply. To create the flux changes necessary to induce voltage in the secondary coil, the direct current in the primary coil is repeatedly interrupted by a vibrating mechanical contact called interrupter.



The spark scoil consists of two coils of insulated wire wound around a common iron core. One coil, called the primary coil, is made from relatively few (tens or hundreds) turns of coarse wire. The other coil, the secondary coil typically consists of up to a million turns of fine wire (up to 40 gauge).

An electric current is passed through the primary, creating a magnetic field. Because of the common core, most of the primary's flux couples with the secondary. When the primary current is suddenly interrupted, the magnetic field rapidly collapses. This causes a high voltage pulse to be developed across the secondary terminals due to electromagnetic induction. Because of the large number of turns in the secondary coil, the secondary voltage pulse is typically many thousands of volts. This voltage is sufficient to create an electric spark, to jump across an air gap separating the secondary's output terminals. For this reason, this induction coils are also called spark coils.

To operate the coil continually, the DC supply current must be repeatedly connected and disconnected. To do that, a magnetically activated vibrating arm called an interrupter is used which rapidly connects and breaks the current flowing into the primary coil. The interrupter is mounted on the end of the coil next to the iron core. When the power is turned on, the produced magnetic field attracts the armature. When the armature has moved far enough, contacts in the primary circuit breaks and disconnects the primary current. Disconnecting the current causes the magnetic field to collapse and create the spark. A short time later the contacts reconnect, and the process repeats.

An arc which may form at the interrupter contacts is undesirable. To prevent this, a capacitor of 0.5 to 15 μF is connected across the primary coil.

Q. 1. The heart of the radio transmitters of Marconi was a

(A) spark coil.

(B) toroid.

(C) RF tuning coil.

(D) Van de Graff generator.

Ans. Option (A) is correct.

> ***Explanation:*** The spark coil designed on the principle of electromagnetic induction was the heart of the earliest radio transmitters. Marconi used a spark coil designed by Heinrich Rhumkorff in his early experiments.

Q. 2. Spark coil is a type of

(A) electrical generator.

(B) electrical transformer.

(C) static electricity generator.

(D) large capacitor.

Ans. Option (B) is correct.

> ***Explanation:*** A spark coil is a type of electrical transformer used to produce high-voltage pulses from a low-voltage (DC) supply. To create the flux changes necessary to induce voltage in the secondary coil, the direct current in the primary coil is repeatedly interrupted by a vibrating mechanical contact called interrupter.

Q. 3. Which of the following statements is correct?

(A) Spark coil consists of two coils of insulated wire. Primary coil, is made from relatively few turns of fine wire. The secondary coil consists of up to a million turns of coarse wire.

(B) Spark coil consists of two coils of insulated wire. Primary coil, is made from a (tens or million turns of coarse wire. The secondary coil consists of up to a few turns of fine wire.

(C) Spark coil consists of two coils of insulated wire. Primary coil, is made from relatively few turns of coarse wire. The secondary coil consists of up to a million turns of fine wire.

(D) Spark coil consists of two coils of insulated wire. Both primary and secondary coil, is made from a million turns of fine wire.

Ans. Option (C) is correct.

Explanation: The spark coil consists of two coils of insulated wire wound around a common iron core. One coil, called the primary coil, is made from relatively few (tens or hundreds) turns of coarse wire. The other coil, the secondary coil typically consists of up to a million turns of fine wire (up to 40 gauge).

Q. 4. Why most of the primary's flux couples with the secondary in spark coil?

(A) Since the primary coil is wound on the secondary coil

(B) Since the primary coil is of thick wire

(C) Since the core is common

(D) None of the above

Ans. Option (C) is correct.

Explanation: The spark coil designed on the principle of electromagnetic induction was the heart of the earliest radio transmitters. Marconi used a spark coil designed by Heinrich Rhumkorff in his early experiments.

Q. 5. What is the function of interrupter in a spark coil?

(A) To rapidly connect and break the current flowing into the primary coil

(B) To rapidly connect and break the current flowing into the secondary coil

(C) to control the formation of spark

(D) None of the above

Ans. Option (A) is correct.

Explanation: To operate the coil continually, the DC supply current must be repeatedly connected and disconnected. To do that, a magnetically activated vibrating arm called an interrupter is used which rapidly connects and breaks the current flowing into the primary coil.

❐❐

CHAPTER

7

Term-I

ALTERNATING CURRENT

Syllabus

- *Alternating currents, peak and RMS value of alternating current/voltage; reactance and impedance; LC oscillations (qualitative treatment only).*
- *LCR series circuit, resonance; power in A.C. circuits*
- *AC generator and transformer.*

STAND ALONE MCQs (1 Mark each)

Q. 1. If the rms current in a 50 Hz AC circuit is 5 A, the value of the current 1/300 s after its value becomes zero is

(A) $5\sqrt{2}$ A **(B)** $5\sqrt{\frac{3}{2}}$A

(C) $\frac{5}{6}$A **(D)** $\frac{5}{\sqrt{2}}$A

Ans. Option (B) is correct.

Explanation: Here, I_{rms} = 5 A, n = 50 Hz and $t = \frac{1}{300} s$

$= \text{Peak value} = \sqrt{2} I_{rms} = \sqrt{2} \times 5 = 5\sqrt{2}$ A

Now, $I = I_0 \sin \omega t = 5\sqrt{2} \sin 2\pi \nu t$

$$= 5\sqrt{2} \sin 2\pi \times 50 \times \frac{1}{300} = 5\sqrt{\frac{3}{2}} \text{ A}$$

Q. 2. An alternating current generator has an internal resistance R_g and an internal reactance X_g. It is used to supply power to a passive load consisting of a resistance R_g and a reactance X_L. For maximum power to be delivered from the generator to the load, the value of X_L is equal to

(A) zero **(B)** X_g

(C) $-X_g$ **(D)** R_g

Ans. Option (C) is correct.

Explanation: As internal resistance of generator is already equal to external resistance *R*g. So to deliver maximum power, *i.e.*, to make reactance equal to zero, the reactance in external circuit will be $- X_g$. In order to deliver maximum power, the generator to the load, the total reactance must be equal to zero, *i.e.*, $X_L + X_g = 0$, $X_L = - X_g$.

Q. 3. When a voltage measuring device is connected to AC mains, the meter shows the steady input voltage of 220 V. this means

(A) input voltage cannot be AC voltage, but a DC voltage.

(B) maximum input voltage is 220 V.

(C) The meter reads not v but (v^2) and is calibrated to read $\sqrt{(v^2)}$.

(D) The pointer of the meter is stuck by some mechanical defect.

Ans. Option (C) is correct.

Explanation: The voltmeter in AC circuit reads value $<v^2>$ and meter is calibrated to rms value $<v^2>$ which is multiplied by $\sqrt{2}$ to get V_{rms}. In other words, voltmeter connected to the AC main read root mean square value of AC voltage, *i.e.*, $\sqrt{<v^2>}$.

Q. 4. 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

Ans. Option (A) is correct.

Explanation: $X_C = 1/2\pi fC$
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.

Q. 5. Relation between r.m.s. voltage and instantaneous voltage of an AC
(A) $V_0 = V_{RMS} / \sqrt{2}$ **(B)** $V_{RMS} = V_0 / \sqrt{2}$
(C) $V_{RMS} = 0.707V_0$ **(D)** Both (C) and (D)

Ans. Option (D) is correct.

Explanation: $V_{rms} = V_0/\sqrt{2} = 0.707V_0$

Q. 6. The heat produced in a given resistance in a given time by the sinusoidal current $I_0 \sin \omega t$ will be the same as heat produced by a steady current of magnitude
(A) $0.707\ I_0$ **(B)** $1.412\ I_0$
(C) I_0 **(D)** $\sqrt{I_0}$

Ans. Option (A) is correct.

Explanation: Heat produced by AC is
Heat produced by DC is I^2R
$I^2_{RMS} = I^2R$
$\therefore I = I_{rms} = I_0/\sqrt{2} = 0.707I_0$

Q. 7. 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.

Ans. Option (A) is correct.

Explanation: In a pure resistive circuit, current and voltage are always in phase.

Q. 8. In which of the following circuit power dissipation is maximum?
(A) Pure capacitive circuit
(B) Pure inductive circuit
(C) Pure resistive circuit
(D) LR or CR circuit

Ans. Option (C) is correct.

Explanation: Since in pure resistive circuit the current and voltage are in phase, the power dissipation is maximum.

Q. 9. 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.

Ans. Option (B) is correct.

Explanation: The resonant frequency of L-C-R series circuit is $v_o = \dfrac{1}{2\pi\sqrt{LC}}$
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.

Q. 10. Which of the following combinations should be selected for better tuning of an L-C-R circuit used for communication?
(A) R = 20 Ω, L = 1.5 H, C = 35 μF
(B) R = 25 Ω, L = 2.5 H, C = 45 μF
(C) R = 15 Ω, L = 3.5 H, C = 30 μF
(D) R = 25 Ω, L = 1.5 H, C = 45 μF

Ans. Option (C) is correct.

Explanation: Quality factor (Q) of an L-C-R circuit is given by,

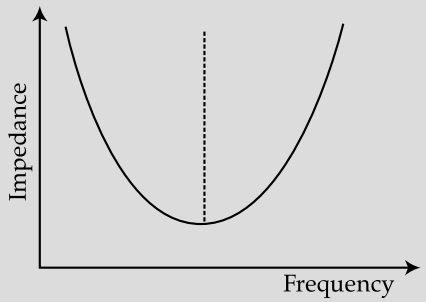
$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

Tuning of an L-C-R circuit depends on quality factor of the circuit. Tuning will be better when quality factor of the circuit is high.
For Q to be high, R should be low, L should be high and C should be low. Therefore, option (C) is most suitable.

Q. 11. 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.

Ans. Option (D) is correct.

Explanation: The frequency vs. impedance graph of a series LCR circuit is as follows:



With increase in frequency, the impedance decreases at first, becomes minimum and then increases.

Q. 12. The sharpness of tuning of a series LCR circuit at resonance is measured by Q factor of the circuit which is given by

(A) $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$ **(B)** $Q = \frac{1}{R}\sqrt{\frac{C}{L}}$

(C) $Q = \frac{1}{L}\sqrt{\frac{R}{C}}$ **(D)** $Q = \frac{1}{C}\sqrt{\frac{R}{L}}$

Ans. Option (A) is correct.

Explanation: Q factor of a series LCR circuit is given by $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$

Q. 13. At resonance, the impedance in series LCR circuit is

(A) maximum. **(B)** zero.

(C) infinity. **(D)** minimum.

Ans. Option (D) is correct.

Explanation: Impedance of a series LCR circuit is $Z = \sqrt{R^2 + (X_C - X_L)^2}$

At resonance, $X_C = X_L$

So, Z is minimum.

Q. 14. The power factor of series LCR circuit at resonance is

(A) 0.707 **(B)** 1

(C) 0.5 **(D)** 0

Ans. Option (B) is correct.

Explanation: At resonance, LCR circuit behaves as purely resistive circuit. For purely resistive circuit, power factor is 1.

Q. 15. When a capacitor C is charged to a certain potential and connected to an inductor L, then frequency of energy oscillation is given by

(A) $\frac{1}{2\pi\sqrt{LC}}$ **(B)** $\frac{1}{\sqrt{LC}}$

(C) $\frac{2\pi}{\sqrt{LC}}$ **(D)** $\frac{1}{2\pi}\sqrt{\frac{L}{C}}$

Ans. Option (A) is correct.

Explanation: When a capacitor C is charged to a certain potential and connected to an inductor L, energy stored in C oscillates between L and C.

$$X_L = X_C$$

$$\therefore \quad f = \frac{1}{2\pi\sqrt{LC}}$$

Q. 16. The output of a step-down transformer is measured to be 24 V when connected to a 12 W Light bulb. The value of the peak current is

(A) $1/\sqrt{2}$ A **(B)** $\sqrt{2}$ A

(C) 2 A **(D)** $2\sqrt{2}$ A

Ans. Option (A) is correct.

Explanation: Given,
Power associated with secondary, P_s = 12 W
Secondary voltage, V_s=24 V

Current in the secondary, $I_s = \frac{P_s}{V_s} = \frac{12}{24} = 0.5\ A$

Peak value of the current in the secondary, $I_0 = I_s\sqrt{2} = (0.5)(1.414) = 0.707$ or $\frac{1}{\sqrt{2}}\ A$.

Q. 17. The underlying principle of transformer is

(A) resonance.

(B) mutual induction.

(C) self induction.

(D) none of the above.

Ans. Option (B) is correct.

Explanation: The transformer is based on the principle of mutual induction which state that due to continuous change in current in the primary coil, an emf is induced across the secondary soil.

Q. 18. 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.

Ans. Option (C) is correct.

Explanation: 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.

Q. 19. 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.

Ans. Option (B) is correct.

Explanation: emf generated = NBA ω sin ω*t*
As ω becomes double, emf generated also becomes double.

Q. 20. Quantity that remains unchanged in a transformer is

(A) voltage. **(B)** current.

(C) frequency. **(D)** none of these.

Ans. Option (C) is correct.

Explanation: Transformer does not change the frequency of the applied AC.

Q. 21. _____ increases in step-down transformer.

(A) Voltage **(B)** Current

(C) Power **(D)** Current density

Ans. Option (B) is correct.

> ***Explanation:*** Since $V_P/V_S = I_S/I_P$, so as as voltage reduces, the current increases in a step-down transformer.

Q. 22. 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

Ans. Option (A) is correct.

> ***Explanation:*** 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 is about 95% to 98%.

ASSERTION AND REASON BASED MCQs (1 Mark each)

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

Q. 1. Assertion (A): An alternating current does not show any magnetic effect.

Reason (R): Alternating current changes direction with time.

Ans. Option (D) is correct.

> ***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.

Q. 2. Assertion (A) : Capacitor blocks *dc* and allows *ac* to pass.

Reason (R): Capacitive reactance is inversely proportional to frequency.

Ans. Option (A) is correct.

> ***Explanation:*** Capacitive reactance = $\frac{1}{2\pi fC}$
>
> 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.

Q. 3. 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.

Ans. Option (B) is correct.

> ***Explanation:*** Given alternating voltage $V = 4\sqrt{2}\sin 314t$.
>
> Where peak value = $V_0 = 4\sqrt{2}$ volt.
> $V_{RMS} = V_0/\sqrt{2} = 4$ volt.
> Hence both assertion and reason both are true. But the reason does not properly explain the assertion.

Q. 4. 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.

Ans. Option (C) is correct.

> ***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.

Q. 5. Assertion (A): The dimension of L/R is time.

Reason (R): Time constant (L/R) should be increased to reduce the rate of increase of current through a solenoid.

Ans. Option (B) is correct.

> ***Explanation:*** For a solenoid, the magnitude of induced emf
>
> $$e = L\frac{di}{dt}$$
>
> $$i = \frac{e}{R} = \left(\frac{L}{R}\right)\left(\frac{di}{dt}\right)$$

$$\frac{di}{dt} = \frac{i}{\frac{L}{R}}$$

In left hand side of the above equation, denominator is time. So, in right hand side, the denominator should be time. So, dimension of L/R is time.
So, the assertion is true.
If L/R increases, di/dt decreases.
So, reason is also true.
But reason cannot properly explain the assertion.

Q. 6. 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.

Ans. Option (D) is correct.

Explanation: 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.

Q. 7. 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 $\tan\varphi = \frac{X_L - X_C}{R}$.

Ans. Option (A) is correct.

Explanation: The angle by which alternating voltage leads the alternating current in series RLC circuit is given by $\tan\varphi = \frac{X_L - X_C}{R}$.

If $X_C < X_L$, then $\tan\varphi$ is positive. φ is also positive. So, e.m.f. leads the current.

Assertion and reason both are true. Reason properly explains the assertion.

Q. 8. Assertion (A): Quality factor of a series LCR circuit is $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$

Reason (R): As bandwidth decreases, Q increases in a resonant LCR circuit.

Ans. Option (B) is correct.

Explanation: Quality factor of a series LCR circuit is $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$. Assertion is true.

Quality factor is also defined as $Q = \frac{\text{Resonant frequency}}{\text{Bandwidth}}$. So, as bandwidth decreases, Q increases. So, reason is also true. But reason does not explain the assertion.

Q. 9. Assertion (A): Principle of operation of AC generator is electromagnetic induction.

Reason (R): Resistance offered by inductor for AC is zero.

Ans. Option (B) is correct.

Explanation: 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.

Q. 10. 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.

Ans. Option (A) is correct.

Explanation: 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.

Q. 11. Assertion (A): A transformer does not work on DC.

Reason (R): DC neither change direction nor magnitude.

Ans. Option (A) is correct.

Explanation: 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.

Q. 12. Assertion (A): A step-up transformer converts input low AC voltage to output high AC voltage.

Reason (R): It violate the law of conservation of energy.

Ans. Option (C) is correct.

Explanation: 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-BASED MCQs

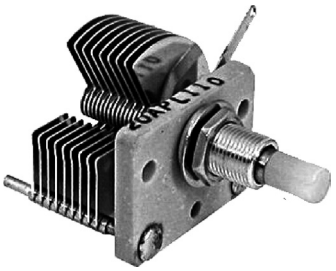
Attempt any 4 sub-parts out of 5. Each sub-part carries 1 mark.

I. Read the following text and answer the following questions on the basis of the same:

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 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.



When capacitive reactance (X_C) is equal to the inductive reactance (X_L), then the resonance occurs and the resonant frequency is given by $\omega_0 = \frac{1}{\sqrt{LC}}$

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 $\frac{V_m}{R}$, the total source voltage appearing across R.

This means that we cannot have resonance in a RL or RC circuit.

Q. 1. Name the phenomenon involved in tuning a radio set to a particular radio station.

(A) Stabilization **(B)** Rectification

(C) Resonance **(D)** Reflection

Ans. Option (C) is correct.

> ***Explanation:*** 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.

Q. 2. Resonance may occur in:

(A) RL circuit.

(B) RC circuit.

(C) LC circuit.

(D) circuit having resistor only.

Ans. Option (C) is correct.

> ***Explanation:*** A 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.

Q. 3. Resonance frequency is equal to:

(A) $\frac{1}{LC}$ **(B)** $1/\sqrt{LC}$

(C) $\sqrt{\frac{L}{C}}$ **(D)** $\sqrt{\frac{C}{L}}$

Ans. Option (B) is correct.

> ***Explanation:*** The resonant frequency is given by $\omega_0 = 1/\sqrt{LC}$

Q. 4. Resonance occurs only when:

(A) $X_C = R$ **(B)** $X_L = R$

(C) $X_L = X_C$ **(D)** $X_C > X_L$

Ans. Option (C) is correct.

> ***Explanation:*** At resonance, capacitive reactance (X_C) is equal to the inductive reactance (X_L). Circuit is totally resistive and the current amplitude becomes maximum.

Q. 5. Capacitor used in radio set for tuning is a:

(A) parallel plate capacitor.

(B) spherical capacitor.

(C) paper capacitor.

(D) electrolytic capacitor.

Ans. Option (A) is correct.

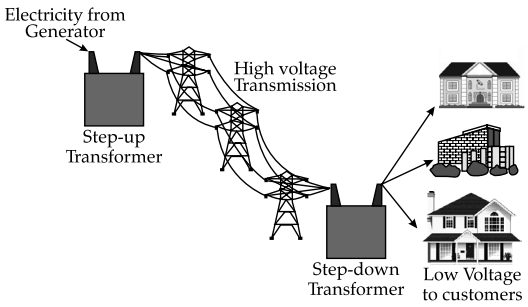
Explanation: Capacitor used in old radio is a parallel plate capacitor. It consists of two sets of parallel circular plates , one of which can rotate manually by means of a knob. The rotation causes overlapping areas of plates to change, thus changing its capacitance.

II. Read the following text and answer the following questions on the basis of the same:

At power plant, a transformer increases the voltage of generated power by thousands of volts so that it can be sent of long distances through high-voltage transmission power lines. Transmission lines are bundles of wires that carry electric power from power plants to distant substations.

At substations, transformers lower the voltage of incoming power to make it acceptable for high-volume delivery to nearby end-users.

Electricity is sent at extremely high voltage because it limits so-called line losses. Very good conductors of electricity also offer some resistance and this resistance becomes considerable over long distances causing considerable loss.



At generating station, normally voltage is stepped up to around thousands of volts. Power losses increase with the square of current. Therefore, keeping voltage high current becomes low and the loss is minimized.

Another option of minimizing loss is the use of wires of super-conducting material. Super-conducting materials are capable of conducting without resistance, they must be kept extremely cold, nearly absolute zero, and this requirement makes standard super-conducting materials impractical to use. However, recent advances in super-conducting materials have decreased cooling requirement. In Germany recently 1 km super-conducting cable have been installed connecting the generating station and the destination. It has eliminated the line loss and the cable is capable of sending five times more electricity than conventional cable. Using super-conducting cables Germany has also get rid of the need of costly transformers.

Transformers generate waste heat when they are in operation and oil is the coolant of choice. It transfers the heat through convection to the transformer housing, which has cooling fins or radiators similar to heat exchangers on the outside.

Flush point is a very important parameter of transformer oil. Flashpoint of an oil is the temperature at which the oil ignites spontaneously. This must be as high as possible (not less than 160° C from the point of safety).

Fire point is the temperature at which the oil flashes and continuously burns. This must be very high for the chosen oil (not less than 200° C).

Q. 1. Which of the following statement is true for long distance transmission of electricity?

(A) Step-down transformer is used at generating station and step-up transformer is used at destination substation.

(B) Step-down transformers are used at generating station and destination substation.

(C) Step-up transformers are used at generating station and destination substation.

(D) None of the above

Ans. Option (D) is correct.

Explanation: At power plant, a step-up transformer increases the voltage of generated power by thousands of volts, so that it can be sent of long distances through high-voltage transmission power lines.

At substations, step-down transformers lower the voltage of incoming power to make it acceptable for high-volume delivery to nearby end-users.

Q. 2. Super-conducting transmission line has the following advantages:

(A) Resistance being zero, there is no I^2R loss.

(B) There is no requirement of costly step-up and step-down transformers.

(C) Cable is capable of sending more electricity.

(D) All of the above

Ans. Option (D) is correct.

Explanation: Super-conducting materials are capable of conducting without resistance. So, this eliminates the line loss and the cable is capable of sending more electricity than conventional cable. Using super-conducting cables, one can get rid of the need of costly transformers.

Q. 3. Why does stepping up voltages reduce power loss?

(A) Since resistance of conductor decreases with increase of voltage

(B) Since current decreases with increase of voltage

(C) Both of the above

(D) None of the above

Ans. Option (B) is correct.

Explanation: At generating station, normally voltage is stepped up to around thousands of volts. Power losses increase with the square of current. Therefore, keeping voltage high, current becomes low and the loss is minimized.

Q. 6. Oil transfers heat from transformer winding by the process of:

(A) convection. **(B)** conduction.

(C) radiation. **(D)** All of these

Ans. Option (A) is correct.

> ***Explanation:*** Transformers generate waste heat when they are in operation and oil is the coolant of choice. It transfers the heat through convection to the transformer housing.

Q. 7. Flush point of an oil is

(A) the temperature at which the oil flashes and continuously burns.

(B) the temperature at which the oil ignites spontaneously.

(C) the temperature at which the oil starts boiling.

(D) The temperature at which the oil forms fumes.

Ans. Option (B) is correct.

> ***Explanation:*** Flush point is a very important parameter of transformer oil. Flashpoint of an oil is the temperature at which the oil ignites spontaneously. This must be as high as possible (not less than 160° C from the point of safety).

III. Read the following text and answer the following questions on the basis of the same:

Losses of transformer

There are 4 types of losses in a transformer: Core loss, Ohmic loss, Stray load loss and dielectric loss.

(1) Core loss

Core loss has two components - hysteresis loss and eddy current loss. These together are called no-load losses of a transformer and are calculated by open circuit test.

(a) Hysteresis loss: This loss mainly depends on the core material used in the transformer. To reduce this loss, the high-grade core material can be used. CRGO- Cold rolled grain oriented Si steel is commonly used for this purpose.

(b) Eddy current loss: This loss can be reduced by designing the core using slight laminations.

These losses are present even when no load is connected. So, these are also known as no-load loss.

(2) Copper Loss

Copper losses occur because of the Ohmic resistance in the windings of the transformer. If the currents in primary and secondary windings of the transformer are I_1 and I_2, and if the resistances of these windings are R_1 & R_2 then the copper losses that occurred in the windings are $I_1^2R_1$ & $I_2^2R_2$ respectively. So, the entire copper loss will be $I_1^2R_1 + I_2^2R_2$.

This loss is also called variable or ohmic losses because this loss changes based on the load.

(3) Stray Loss

These types of losses in a transformer occur because of the occurrence of the leakage flux. As compared with copper and iron losses, the percentage of stray losses are less, so these losses can be neglected.

(4) Dielectric Loss

This loss mainly occurs within the oil of the transformer. Oil is an insulating material. Once the oil quality in the transformer deteriorates then the transformer's efficiency is affected.

Efficiency of Transformer

It is the ratio of output power and input power.

Efficiency = Output Power / Input Power.

The transformer is a highly efficient device which ranges between 95% – 98.5%.

Q.1. What is the relationship among core loss, hysteresis loss and eddy current loss?

(A) Eddy current loss = Core loss + Hysteresis loss

(B) Core loss = Hysteresis loss + eddy current loss

(C) Hysteresis loss = Core loss + eddy current loss

(D) Core loss = Hysteresis loss X eddy current loss

Ans. Option (B) is correct.

Q. 2. Which of the following losses in transformer is also known as no-load loss?

(A) Copper loss **(B)** Stray loss

(C) Dielectric loss **(D)** Core loss

Ans. Option (D) is correct.

> ***Explanation:*** Core loss is present even when no load is connected. So, these are also known as no-load loss.

Q.3. Which of the following losses in transformer is also known as variable loss?

(A) Copper loss **(B)** Stray loss

(C) Dielectric loss **(D)** Core loss

Ans. Option (A) is correct.

> ***Explanation:*** If the currents in primary and secondary windings of the transformer are I_1 and I_2 respectively and the resistances of these windings are R_1 and R_2 then the copper losses that occurred in the windings are $I_1^2R_1$ and $I_2^2R_2$ respectively. So, the entire copper loss will be $I_1^2R_1 + I_2^2R_2$.
>
> This loss is also called variable or ohmic losses because this loss changes based on the load.

Q. 4. How hysteresis loss can be reduced?

(A) Using core of Si Steel

(B) Using laminated core

(C) Using core of non-ferro magnetic material

(D) Using oil of higher dielectric constant

Ans. Option (A) is correct.

Q. 5. Specify the range of transformer efficiency.

(A) 10-15% **(B)** 95-98%

(C) 50-60% (d) 40-50%

Ans. Option (B) is correct.

❐❐

PART – VIII : ELECTROMAGNETIC WAVES

CHAPTER 8

Term-II

ELECTROMAGNETIC WAVES

Syllabus

- *Basic idea of displacement current, Electromagnetic waves, their characteristics, their Transverse nature, qualitative ideas only.*
- *Electromagnetic spectrum (radio waves, microwaves, infrared, visible, ultraviolet, X-rays, gamma rays) including elementary facts about their uses.*

STAND ALONE MCQs (1 Mark each)

Q. 1. A linearly polarized electromagnetic wave given as $\mathbf{E} = E_0\, i \cos(kz - \omega t)$ is incident normally on a perfectly reflecting infinite wall at $z = a$. Assuming that the material of the wall is optically inactive, the reflected wave will be given as

(A) $E_r = -E_0 \hat{i} \cos(kz - \omega t)$

(B) $E_r = E_0 \hat{i} \cos(kz + \omega t)$

(C) $E_r = -E_0 \hat{i} \cos(kz + \omega t)$

(D) $E_r = E_0 \hat{i} \sin(kz - \omega t)$

Ans. Option (B) is correct.

Explanation: The phase of a wave changes by 180° or π radian after got reflected from a denser medium. But the type of waves remains identical.

Therefore, for the reflected wave, we have $\hat{z} = -\hat{z}$, $\hat{i} = -\hat{i}$ and additional phase of π in the incident wave.

Incident electromagnetic wave. Then,

$$E = E_0(-\hat{i})\cos(kz - \omega t)$$

Therefore, the reflected electromagnetic wave is given as:

$$E_r = E_0(-\hat{i})\cos[k(-z) - \omega t + \pi]$$

$$[\because \hat{z} = -\hat{z} \text{ and } \hat{i} = -\hat{i}]$$

$$= -E_0\hat{i}\cos[\pi - (kz + \omega t)]$$

$$= -E_0\hat{i}[-\cos\{(kz + \omega t)\}]$$

$$= E_0\hat{i}\cos(kz + \omega t)$$

Q. 2. Light with an energy flux of 20 W/cm^2 falls on a non-reflecting surface at normal incidence. If the surface has an area of 30 cm^2, the total momentum delivered (for complete absorption) during 30 minutes is

(A) 36×10^{-5} kg m/s. **(B)** 36×10^{-4} kg m/s.

(C) 108×10^{4} kg m/s. **(D)** 1.08×10^{7} kg m/s.

Ans. Option (B) is correct.

Explanation: Energy flux, $\phi = 20$ W/cm^2

Area A= 30 cm^2, time t=30×60 sec

U = Total energy falling in t sec= Energy flux × Area × time = $\phi A t$

U= 20×30×30×60 J

Momentum of the incident light

$$= \frac{u}{c} = \frac{20 \times 30 \times 30 \times 60}{3 \times 10^8} = 36 \times 10^{-4}\ \text{kg-ms}^{-1}$$

As no reflection from the surface and for complete absorption, momentum of reflected radiation is zero.

Momentum delivered to surface = Change in momentum

$$= p_f - p_i = 0 - 36 \times 10^{-4}\ \text{kgm/s}$$

$$= -36 \times 10^{-4}\ \text{kg m/s}$$

(–) sign shows the direction of momentum.

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

(A) $\frac{E}{2}$ **(B)** 2E

(C) $\frac{E}{\sqrt{2}}$ **(D)** $\sqrt{2}$E

Ans. Option (C) is correct.

Explanation: We know that,

$$E_0 \propto \sqrt{P_{av}}$$

$$\frac{(E_0)_1}{(E_0)_2} = \sqrt{\frac{(P_{av})_1}{(P_{av})_2}} = \sqrt{\frac{100\ W}{50\ W}} = \frac{\sqrt{2}}{1}$$

$$\therefore (E_0)_2 = \frac{(E_0)_1}{\sqrt{2}}$$

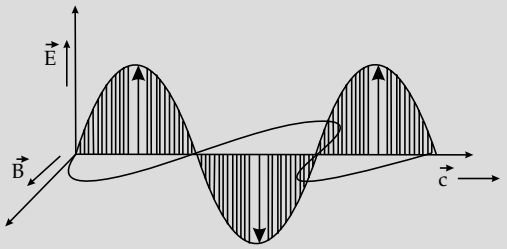
Q. 4. If $\vec{E}$ and $\vec{B}$ represent electric and magnetic field vectors of the electromagnetic wave, the direction of propagation of electromagnetic wave is along

(A) $\vec{}$ **(B)** $\vec{B}$

(C) $\vec{B} \times \vec{E}$ **(D)** $\vec{E} \times \vec{B}$

Ans. Option (D) is correct.

Explanation: The direction of propagation of electromagnetic wave is perpendicular to $\vec{E}$ and $\vec{B}$ both and by right thumb rule.



The direction of propagation of electromagnetic wave is perpendicular to both the electric field vector $\vec{E}$ and $\vec{B}$ magnetic field vector *B*, *i.e.*, in the direction of $\vec{E}$ and $\vec{B}$.

Here, electromagnetic wave is along the z-direction which is given by the cross product of $\vec{E}$ and $\vec{B}$.

Q. 5. The ratio of contributions made by the electric field and magnetic field components to the intensity of an EM wave is

(A) $c : 1$ **(B)** $c^2 : 1$

(C) 1 : 1 **(D)** $\sqrt{c} : 1$

Ans. Option (C) is correct.

Explanation: Average energy by electric field E_0 is U_{av}

$$U_{av} = \frac{1}{2}\varepsilon_0 E_0^2$$

But $E_0 = cB_0$

$$(U_{av})_{\text{electric field}} = \frac{1}{2}\varepsilon_0 (cB_0)^2 = \frac{1}{2}\varepsilon_0 c^2 B_0^2$$

$$= \frac{1}{2}\varepsilon_0 . \frac{1}{\mu_0 \varepsilon_0} (B_0)^2 \quad \because c^2 = \frac{1}{\mu_0 \varepsilon_0}$$

$$(U_{av})_{\text{electric field}} = \frac{1}{2\mu_0} B_0^2 (U_{av})_{(\text{magnetic field})}$$

$$\text{Ratio} = \frac{(U_{av})\ \text{electric field}}{(U_{av})\ \text{magnetic field}}$$

$$= \frac{1}{1}, \textit{i.e.}, \ 1 : 1$$

Q. 6. An EM wave radiates outwards from a dipole antenna, with E_0 as the amplitude of its electric field vector. The electric field E_0 which transports significant energy from the source falls off as

(A) $\frac{1}{r^3}$ **(B)** $\frac{1}{r^2}$

(C) $\frac{1}{r}$ **(D)** remains constant

Ans. Option (C) is correct.

Explanation: A diode antenna radiates the electromagnetic waves outwards. The amplitude of electric field vector (E_0) which transports significant energy from the source falls inversely as the distance (*r*) from the antenna. As we know that electromagnetic waves are radiated from dipole antenna and radiated energy, so $E \propto \frac{1}{r}$.

Q. 7. In electromagnetic waves, the phase difference between magnetic and electric field vectors is

(A) zero (B) π

(C) π/2 (D) π/4

Ans. Option (A) is correct.

Explanation: Peaks of magnetic and electric waves of electromagnetic wave form at the same time. Hence, there is no phase difference between these two waves.

Q. 8. From Maxwell's hypothesis, a changing electric field gives rise to

(A) an electric field **(B)** an induced emf

(C) a magnetic field **(D)** a magnetic torque.

Ans. Option (C) is correct.

Explanation: A changing magnetic field induces an electromotive force (emf) and, hence, an electric field. The direction of the emf opposes the change. The third Maxwell's equations is Faraday's law of induction, and includes Lenz's law.

Q. 9. One requires 11 eV of energy to dissociate a carbon monoxide molecule into carbon and oxygen atoms. The minimum frequency of the appropriate electromagnetic radiation to achieve the dissociation lies in

(A) visible region **(B)** infrared region

(C) ultraviolet region **(D)** microwave region

Ans. Option (C) is correct.

Explanation: $E = 11 \text{ eV} = 11 \times 1.6 \times 10^{-19} \text{ J}$

$h = 6.62 \times 10^{-34}$ Js

$E = h\nu$

$$\nu = \frac{E}{h} = \frac{11 \times 1.6 \times 10^{-19}}{6.62 \times 10^{-34}} = \frac{8.8 \times 10^{-19+34}}{3.31}$$

$$= \frac{880}{331} \times 10^{15} \text{ Hz} = 2.65 \times 10^{15} \text{ Hz}$$

This frequency radiation belongs to the ultraviolet region.

Q. 10. The phenomenon which shows quantum nature of electromagnetic radiation is

(A) Piezoelectric effect **(B)** Photoelectric effect

(C) Hall effect **(D)** Tyndall effect

Ans. Option (B) is correct.

Explanation: Photoelectric effect allows us to perceive the quantum nature of light and ultimately electromagnetic radiation.

Q. 11. The electromagnetic radiations used for water purification and eye surgery is

(A) Infrared **(B)** Microwave

(C) X-rays **(D)** None of the above

Ans. Option (D) is correct.

Explanation: Ultraviolet rays are used for water purification and eye surgery.

Q. 12. Electromagnetic wave having frequency 5×10^{11} Hz is

(A) Ultraviolet wave **(B)** Radio wave

(C) Microwave **(D)** X-rays

Ans. Option (C) is correct.

Explanation: Microwave frequency ranges from 10^{13} to 10^{9} Hz.

Q. 13. Proper arrangement of Gamma rays, Microwave, IR wave and UV rays in ascending order of frequency is

(A) Gamma rays > UV rays > IR rays > Microwave

(B) Microwave > IR rays > UV rays > Gamma rays

(C) UV rays > Gamma rays > Microwave > IR rays

(D) IR rays > UV rays > Microwave > Gamma rays

Ans. Option (A) is correct.

Explanation: Frequency range of Gamma rays: $10^{22} - 10^{19}$ Hz

Frequency range of UV rays: $10^{17} - 10^{15}$ Hz

Frequency range of IR rays: $10^{14} - 10^{12}$ Hz

Frequency range of Microwave: $10^{13} - 10^{9}$ Hz

Q. 14. In vacuum, the physical property which remains same for microwave of wavelength 1 mm and UV radiation 1600 Å is

(A) Wavelength **(B)** Frequency

(C) Speed **(D)** None of the above

Ans. Option (C) is correct.

Explanation: All types of electromagnetic waves travel with speed of light in vacuum.

Q. 15. In vacuum, the wavelength of the electromagnetic wave of frequency 5×10^{19} Hz is

(A) 6×10^{-12} m **(B)** 3×10^{-8} m

(C) 1.6×10^{11} m **(D)** 15×10^{27} m

Ans. Option (A) is correct.

Explanation: $\lambda = v/c = \dfrac{3 \times 10^{8}}{5 \times 10^{19}} = 6 \times 10^{-12}$ m

Q. 16. Which one of the following statements are correct?

(A) X-rays are suitable for radar system and aircraft navigation.

(B) Water molecules readily absorb infrared radiation and their thermal motion increases.

(C) Microwaves are produced in Coolidge tube

(D) Gamma radiations generate due to electron transitions between upper and lower energy levels of heavy element when excited by electron bombardment

Ans. Option (B) is correct.

Explanation: Water molecules readily absorb infrared radiation and their thermal motion increases and therefore, they heat their surroundings.

ASSERTION AND REASON BASED MCQs (1 Mark each)

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

Q. 1. Assertion (A): Electromagnetic radiation exerts pressure.

Reason (R): Electromagnetic waves carry momentum and energy.

Ans. Option (B) is correct.

> ***Explanation:*** Electromagnetic radiation is composed of photons which has momentum (λ/h) and energy ($h\nu$). When photon is incident on a surface, its momentum changes which gives rise to radiation pressure.
> So, the assertion and reason both are true but the reason does not explain the assertion.

Q. 2. Assertion (A): Electromagnetic wave does not require any medium to travel.
Reason (R): Electromagnetic wave cannot travel through any medium.

Ans. Option (C) is correct.

> ***Explanation:*** Electromagnetic waves are not mechanical waves. Hence, they do not require any medium to travel. It does not mean that electromagnetic wave cannot travel through a medium. Hence the assertion is true. But the reason is false.

Q. 3. Assertion (A): Dipole oscillation produce electromagnetic waves.
Reason (R): Accelerated charge produce electromagnetic waves.

Ans. Option (A) is correct.

> ***Explanation:*** A source of electromagnetic waves is accelerating charge, since accelerated charge produces both electric and magnetic field. Again according to Maxwells' classical theory, dipole oscillation produces electromagnetic wave, since charges are accelerated. So, assertion and reason both are true and the reason explains the assertion.

Q. 4. Assertion (A): X-ray travels with the speed of light.
Reason (R): X-ray is an e.m. wave. **1**

Ans. Option (A) is correct.

> ***Explanation:*** Velocity of all electromagnetic wave is 3×10^8 m/s which is the velocity of light.
> X-ray is an electromagnetic wave. So, it travels with the velocity 3×10^8 m/s which is the velocity of light.
> So, assertion and reason both are correct and reason properly explains the assertion.

Q. 5. Assertion (A): Microwaves are considered suitable for radar system.
Reason (R): Microwaves are of shorter wavelength.

Ans. Option (A) is correct.

> ***Explanation:*** Wavelength of microwaves ranges from 10^{-3} to 0.1 m. Hence, it can be bounced from any small object. Hence, it is suitable for radar system. So, the assertion and reason both are true and the assertion is properly explained by the reason.

Q. 6. Assertion(A): The Ozone layer present at the top of stratosphere is very crucial for human survival.
Reason (R): Ozone layer prevents IR radiation.

Ans. Option (C) is correct.

> ***Explanation:*** There is a layer present at the top of stratosphere which is known as Ozone layer. This layer prevents UV radiations, mainly coming from the Sun, to reach Earth. UV radiation is harmful for human beings. So, the assertion is true. But the reason is false.

Q. 7. Assertion (A): Gamma rays are electromagnetic waves having the smallest wavelength.
Reason (R): Gamma rays are having the lowest frequency.

Ans. Option (C) is correct.

> ***Explanation:*** Gamma rays are electromagnetic waves having the smallest wavelength. So, the assertion is true.
> Relation between wavelength and frequency is $\nu = c/\lambda$.
> c is the velocity of light and same for all electromagnetic waves. For Gamma rays wavelength being smallest, frequency will be highest. So, the reason is false.

CASE-BASED MCQs

Attempt any 4 sub-parts out of 5. Each sub-part carries 1 mark.

I. Read the following text and answer the following questions on the basis of the same:

Microwave oven:

The spectrum of electromagnetic radiation contains a part known as microwaves. These waves have frequency and energy smaller than visible light and wavelength larger than it. What is the principle of a microwave oven and how does it work ? Our objective is to cook food or warm it up. All food items such as fruit, vegetables, meat, cereals, etc., contain water as a constituent. Now, what does it mean when we say that a certain object has become warmer? When the temperature of a body rises, the energy of the random motion of atoms and molecules increases and the molecules travel or vibrate or rotate with higher energies. The frequency of rotation of water molecules is about 2.45 gigahertz (GHz). If water receives microwaves of this frequency, its molecules absorb this radiation, which is equivalent to heating up water. These molecules share this energy with neighbouring food molecules, heating up the

food. One should use porcelain vessels and non metal containers in a microwave oven because of the danger of getting a shock from accumulated electric charges. Metals may also melt from heating. The porcelain container remains unaffected and cool, because its large molecules vibrate and rotate with much smaller frequencies, and thus cannot absorb microwaves. Hence, they do not get eaten up. Thus, the basic principle of a microwave oven is to generate microwave radiation of appropriate frequency in the working space of the oven where we keep food. This way energy is not wasted in heating up the vessel. In the conventional heating method, the vessel on the burner gets heated first and then the food inside gets heated because of transfer of energy from the vessel. In the microwave oven, on the other hand, energy is directly delivered to water molecules which is shared by the entire food.

Q. 1. As compared to visible light microwave has frequency and energy:

(A) more than visible light.

(B) less than visible light.

(C) equal to visible light.

(D) Frequency is less but energy is more

Ans. Option (B) is correct.

> ***Explanation:*** Microwaves have frequency and energy smaller than visible light and wavelength larger than it.

Q. 2. When the temperature of a body rises:

(A) the energy of the random motion of atoms and molecules increases.

(B) the energy of the random motion of atoms and molecules decreases.

(C) the energy of the random motion of atoms and molecules remains same.

(D) the random motion of atoms and molecules becomes streamlined.

Ans. Option (A) is correct.

> ***Explanation:*** When the energy of the random motion of atoms and molecules of a substance increases and the molecules travel or vibrate or rotate with higher energies, the substance becomes hot.

Q. 3. The frequency of rotation of water molecules is about:

(A) 2.45 MHz. **(B)** 2.45 kHz.

(C) 2.45 GHz. **(D)** 2.45 THz.

Ans. Option (C) is correct.

> ***Explanation:*** The frequency of rotation of water molecules is about 2.45 gigahertz.

Q. 4. Why should one use porcelain vessels and non-metal containers in a microwave oven ?

(A) Because it will get too much hot.

(B) Because it may crack due to high frequency.

(C) Because it will prevent the food items to become hot.

(D) Because of the danger of getting a shock from accumulated electric charges.

Ans. Option (D) is correct.

> ***Explanation:*** One should use porcelain vessels and non-metal containers in a microwave oven because of the danger of getting a shock from accumulated electric charges. Metals may also melt from heating. The porcelain container remains unaffected and cool, because its large molecules vibrate and rotate with much smaller frequencies and thus cannot absorb microwaves. Hence, they do not get heated up.

Q. 5. In the microwave oven,

(A) energy is directly delivered to water molecules which is shared by the entire food.

(B) the vessel gets heated first, and then the food grains inside.

(C) the vessel gets heated first and then the water molecules collect heat from the body of the vessel.

(D) energy is directly delivered to the food grains.

Ans. Option (A) is correct.

> ***Explanation:*** In the conventional heating method, the vessel on the burner gets heated first and then the food inside gets heated because of transfer of energy from the vessel. In the microwave oven, on the other hand, energy is directly delivered to water molecules which is shared by the entire food.

II. Read the following text and answer the following questions on the basis of the same:

Laser:

Electromagnetic radiation is a natural phenomenon found in almost all areas of daily life, from radio waves to sunlight to x-rays. Laser radiation – like all light – is also a form of electromagnetic radiation. Electromagnetic radiation that has a wavelength between 380 nm and 780 nm is visible to the human eye and is commonly referred to as light. At wavelengths longer than 780 nm, optical radiation is termed infrared (IR) and is invisible to the eye. At wavelengths shorter than 380 nm, optical radiation is termed ultraviolet (UV) and is also invisible to the eye. The term "laser light" refers to a much broader range of the electromagnetic spectrum that just the visible spectrum, anything between 150 nm up to 11000 nm (*i.e.* from the UV up to the far IR). The term laser is an acronym which stands for "light amplification by stimulated emission of radiation".

Einstein explained the stimulated emission. In an atom, electron may move to higher energy level by absorbing a photon. When the electron comes back to the lower energy level it releases the same

photon. This is called spontaneous emission. This may also so happen that the excited electron absorbs another photon , releases two photons and returns to the lower energy state. This is known as stimulated emission.

Laser emission is therefore a light emission whose energy is used, in lithotripsy, for targeting and ablating the stone inside human body organ.

Apart from medical usage, laser is used for optical disk drive, printer, barcode reader etc.

Q. 1. What is the full form of LASER ?

(A) Light amplified by stimulated emission of radiation

(B) Light amplification by stimulated emission of radiation

(C) Light amplification by simultaneous emission of radiation

(D) Light amplified by synchronous emission of radiation

Ans. Option (B) is correct.

> ***Explanation:*** The term laser is an acronym which stands for "light amplification by stimulated emission of radiation".

Q. 2. The "stimulated emission" is the process of :

(A) release of a photon when electron comes back from higher to lower energy level.

(B) release of two photons by absorbing one photon when electron comes back from higher to lower energy level.

(C) absorption of a photon when electron moves from lower to higher energy level.

(D) None of the above

Ans. Option (B) is correct.

> ***Explanation:*** Einstein explained the stimulated emission. In an atom, electron may move to higher energy level by absorbing a photon. When the electron comes back to the lower energy level, it releases the same photon. This is called spontaneous emission. This may also so happen that the excited electron absorbs another photon, releases two photons and returns to the lower energy state. This is known as stimulated emission.

Q. 3. What is the range of amplitude of LASER?

(A) 150 nm – 400 nm

(B) 700 nm – 11000 nm

(C) Both the above

(D) None of the above

Ans. Option (C) is correct.

> ***Explanation:*** The term "laser light" refers to a much broader range of the electromagnetic spectrum that just the visible spectrum, anything between 150 nm up to 11000 nm (*i.e.* from the UV up to the far IR).

Q. 4. Lithotripsy is:

(A) an industrial application.

(B) a medical application.

(C) laboratory application.

(D) process control application.

Ans. Option (B) is correct.

> ***Explanation:*** Laser emission is therefore a light emission whose energy is used, in lithotripsy, for targeting and ablating the stone inside human body organ.

Q. 5. LASER is used in:

(A) optical disk drive.

(B) transmitting satellite signal.

(C) radio communication.

(D) ionization.

Ans. Option (A) is correct.

> ***Explanation:*** An optical disc drive (ODD) is a disc drive that uses laser light or electromagnetic waves within or near the visible light spectrum as part of the process of reading or writing data to form optical discs.

III. Read the following text and answer the following questions on the basis of the same:

Ozone layer depletion:

We are all exposed to UV radiation from the sun. The sun is by far the strongest source of ultraviolet radiation. UV radiation spectrum is divided into three regions called UVA, UVB and UVC. As sunlight passes through the atmosphere, all UVC and most UVB is absorbed by ozone, water vapour, oxygen and carbon dioxide. UVA is not filtered as significantly by the atmosphere.

The three types of UV radiation are classified according to their wavelength. They differ in their biological activity and the extent to which they can penetrate the skin. The shorter the wavelength, the more harmful the UV radiation.

The UV region covers the wavelength range 100-400 nm and is divided into three bands:

- UVA (315-400 nm)
- UVB (280-315 nm)
- UVC (100-280 nm).

Short-wavelength UVC is the most damaging type of UV radiation. However, it is completely filtered by the atmosphere and does not reach the earth's surface.

UV level reaching the earth changes with latitude and altitude.

UV levels are higher closer to the equator. Closer to the equator the sun's rays have a shorter distance to travel through the atmosphere and therefore harmful UV radiation absorption is less.

With increasing altitude less atmosphere is available to absorb UV radiation. With every 1000 m in altitude, UV levels increase by approximately 10%.

Ozone is a particularly effective absorber of UV radiation. As the ozone layer gets thinner, the protective filter activity is progressively reduced. Consequently, the people and the environment are exposed to higher levels of UV radiation, especially UVB.

Ozone depletion is caused by human-made chemicals released into the atmosphere.

Q. 1. How many bands are there in UV radiation spectrum?

(A) 2 **(B)** 5

(C) 3 **(D)** 4

Ans. Option (C) is correct.

> ***Explanation:*** There are 3 bands in UV spectrum – UVA, UVB, UVC.
> UVA (315-400 nm)
> UVB (280-315 nm)
> UVC (100-280 nm).

Q. 2. Most harmful UV radiation band is

(A) UVA **(B)** UVB

(C) UVC **(D)** all of them

Ans. Option (C) is correct.

> ***Explanation:*** The shorter the wavelength, the more harmful the UV radiation. UVC has the shortest wavelength.

Q. 3. Which UV band is not absorbed by the atmosphere?

(A) UVA **(B)** UVB

(C) UVC **(D)** none of them

Ans. Option (A) is correct.

> ***Explanation:*** UVA is not filtered significantly by the atmosphere.

Q. 4. Ozone layer depletion is caused by

(A) cosmic rays.

(B) human-made chemicals released into the atmosphere.

(C) electrical spark in the atmosphere.

(D) None of the above

Ans. Option (B) is correct.

> ***Explanation:*** Ozone depletion is caused by human-made chemicals released into the atmosphere.

Q. 5. UV level is

(A) low at equator, high at poles.

(B) low at poles, high at equator.

(C) same at pole and equator.

(D) None of the above

Ans. Option (B) is correct.

> ***Explanation:*** UV level is higher at the equator compared to that at poles. Closer to the equator, the Sun's rays have a shorter distance to travel through the atmosphere and therefore, harmful UV radiation absorption is less.

❐❐

PART – VI : OPTICS

Term-II

CHAPTER 9

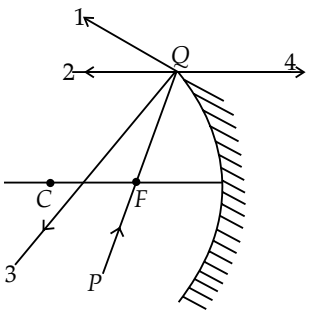
RAY OPTICS AND OPTICAL INSTRUMENTS

Syllabus

- ***Ray Optics:*** *Refraction of light, total internal reflection and its applications, optical fibers, refraction at spherical surfaces, lenses, thin lens formula, lensmaker'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.*

STAND ALONE MCQs (1 Mark each)

Q. 1. The direction of ray of light incident on a concave mirror is shown by PQ while directions in which the ray would travel after reflection is shown by four rays marked 1, 2, 3 and 4 (Figure). Which of the four rays correctly shows the direction of reflected ray?



(A) 1 **(B)** 2
(C) 3 **(D)** 4

Ans. Option (B) is correct.

Explanation: Incidence ray PQ is coming through principal focus F so it must be parallel to principal axis, that is, either 2 or 4.
As it is a concave mirror so, ray cannot go behind the mirror so ray (4) is discarded.
So, ray 2 is the reflected ray that verifies answer (B).

Q. 2. A car is moving with at a constant speed of 60 km h^{-1} on a straight road. Looking at the rear-view mirror, the driver finds that the car following him is at a distance of 100 m and is approaching with a speed of 5 km h^{-1}. In order to keep track of the car in the rear, the driver begins to glance alternatively at the rear and side mirror of his car after every 2 s till the other car overtakes. If the the following statement(s) is/are correct?

(A) The speed of the car in the rear is 65 km/h.

(B) In the side mirror the car in the rear would appear to approach with a speed of 5 km h^{-1} to the driver of the leading car.

(C) In the rear view mirror the speed of the approaching car would appear to decrease as the distance between the cars decreases.

(D) In the side mirror, the speed of the approaching car would appear to increase as the distance between the cars decreases.

Ans. Option (D) is correct.

Explanation: When rear car approaches, initially it appears at rest as image is formed at focus. When car approaches nearer this speed will appear to increase.

Q.3. When an object is placed between f and $2f$ of a concave mirror, the image formed is

(A) Real, diminished **(B)** Real, magnified
(C) Virtual, diminished **(D)** Virtual, magnified

Ans. Option (B) is correct.

> ***Explanation:*** When an object is placed between f and $2f$ of a concave mirror, the image is formed beyond $2f$. The image is real and magnified.

Q. 4. _____ mirror has real focus.
(A) Concave **(B)** Convex
(C) Plane **(D)** all of the above

Ans. Option (A) is correct.

> ***Explanation:*** In concave mirror, parallel rays after reflection from the mirror actually meet at a point. This point is is known is focus. Hence the focus is real.

Q. 5. In two positions concave mirror produces magnified image of given object. The positions are
(A) (i) At C, (ii) at F
(B) (i) Between F and C, (ii) Between P and F
(C) (i) Beyond C, (ii) Between P and F
(D) (i) At C, (ii) between P and F

Ans. Option (B) is correct.

> ***Explanation:*** When the object is placed between C and F in front of a concave mirror, the imager is formed beyond C. Image is magnified, real and inverted.
> When the object is placed between P and F in front of a concave mirror, the image is formed behind the mirror. Image is magnified, virtual and erect.

Q. 6. Convex mirrors are preferred over plane mirrors as rear view mirror in automobile since
(A) the image formed is magnified.
(B) the image formed is real.
(C) the field of view is large.
(D) it is light weight.

Ans. Option (C) is correct.

> ***Explanation:*** Convex mirrors are preferred over plane mirrors as rear view mirror in automobile since these mirrors have larger field of view compared to plane and concave mirror.

Q. 7. The focal length of a concave mirror is f. An object is placed at a distance x fron the focus. The magnification is
(A) $f+x)/f$ **(B)** f/x
(C) x/f **(D)** $f/(f+x)$

Ans. Option (B) is correct.

> ***Explanation:*** $u = f + x$
> Using mirror formula,
> $1/v + 1/u = 1/f$
> Or, $1/v - 1/(f+x) = -1/f$
> $\therefore v = -f(f+x)/x$
> So, the magnification $= |m| = v/u = f/x$

Q. 8. In a concave mirror, an object is placed at a distance x_1 from the focus. Image if formed at a distance x_2 from the focus. The focal length of the mirror is
(A) x_1x_2. **(B)** $x_1 + x_2$.
(C) x_1/x_2. **(D)** None of these

Ans. Option (D) is correct.

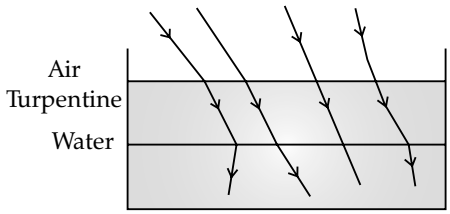
> ***Explanation:*** $u = f + x_1$
> $v = f + x_2$
> $f = uv/(u+v)$
> or, $f = \dfrac{(f+x_1)(f+x_2)}{(f+x_1)+(f+x_2)}$
> or $f_2 = x_1x_2$
> $\therefore f = \sqrt{x_1 x_2}$

Q. 9. The phenomena involved in the reflection of radio waves by ionosphere are similar to
(A) reflection of light by a plane mirror.
(B) total internal reflection of light in air during a mirage.
(C) dispersion of light by water molecules during the formation of a rainbow.
(D) scattering of light by the particles of air.

Ans. Option (B) is correct.

> ***Explanation:*** Radiowaves are reflected by a layer of atmosphere called the Ionosphere, so they can reach distant parts of the Earth. The reflection of radiowaves by ionosphere is due to total internal reflection. It is the same as total internal reflection of light in air during a mirage, that is, angle of incidence is greater than critical angle.
> Ionosphere is transparent optical medium and radiowave is reflected back.
> Reflection through transparent surface is total internal reflection so that internal reflection of radio wave takes place.

10. The optical density of turpentine is higher than that of water while its mass density is lower. Figure shows a layer of turpentine floating over water in a container. For which one of the four rays incident on turpentine in Figure, the path shown is correct?



(A) 1 **(B)** 2
(C) 3 **(D)** 4

Ans. Option (B) is correct.

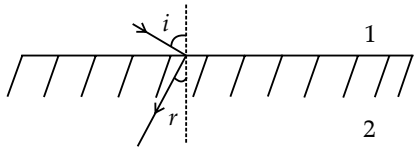
Explanation : $\mu_A < \mu_T > \mu_W$
As incidence ray passes from air to turpentine to water it means, from rare to denser then denser to rarer so first it bends towards normal then away from normal so the path shown is correct for ray (2).

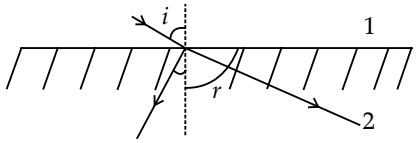
Q. 11. A short pulse of white light is incident from air to a glass slab at normal incidence.
After travelling through the slab, the first colour to emerge is
(A) blue. **(B)** green.
(C) violet. **(D)** red.

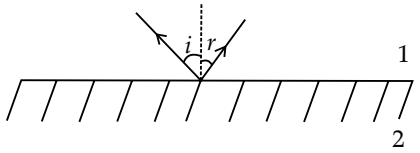
Ans. Option (D) is correct.

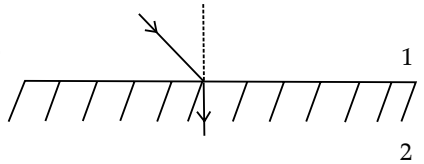
Explanation: As we know that the velocity of wave is :
$v = \nu\lambda$
When light ray goes from one medium to other medium, the frequency of light remains unchanged.
So, $v \propto \lambda$ or greater the wavelength, greater the speed.
And, the light of red colour is of highest wavelength and therefore of highest speed. So, after travelling through the slab, the red colour emerges first.

Q. 12. There are certain materials developed in laboratories which have a negative refractive index (Figure). A ray incident from air (medium 1) into such a medium (medium 2) shall follow a path given by :

(A)


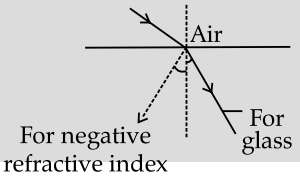
(B)


(C)


(D)


Ans. Option (A) is correct.

Explanation: The negative refractive index materials are those in which incident materials are those in which incident ray from air (medium 1) to them refract or bends differently or opposite and symmetric to normal to that of positive refractive index medium.



Q. 13. The radius of curvature of the curved surface of a plano-convex lens is 20 cm. If the refractive index of the material of the lens be 1.5, it will
(A) act as a convex lens only for the objects that lie on its curved side.
(B) act as a concave lens for the objects that lie on its curved side.
(C) act as a convex lens irrespective of the side on which the object lies.
(D) act as a concave lens irrespective of side on which the object lies.

Ans. Option (C) is correct.

Explanation: As we know the relations between f, μ, R_1 and R_2 is known as lens maker's formula :

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

$R_1 = \infty$, $R_2 = -R$

$$f = \frac{R}{(\mu - 1)}$$

Given that,
R=20 cm,
μ =1.5
Put the values;

$$f = \frac{R}{\mu - 1} = \frac{20}{15 - 1} = 40 \text{ cm}$$

As $f > 0$, it means converging nature of the lens.
So, lens act as a convex lens irrespective of the side on which the object lies.

Q. 14. Radius of curvature of human eye is 0.78 cm. For an object at infinity, image is formed at 3 cm behind the refracting surface. The refractive index of eye is
(A) 1.35 **(B)** 3
(C) 6.2 **(D)** 1

Ans. Option (A) is correct.

Explanation: $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$

Putting $v = 3$ cm

$\mu_1 = 1$

$u = \infty$

R = 0.78 cm

$\frac{\mu_2}{3} - \frac{1}{\infty} = \frac{\mu_2 - 1}{0.78}$

$\therefore \mu_2 = 1.35$

Q. 15. The relationship between angle of incidence i, prism of angle A and angle of minimum deviation for a triangular prism is

(A) $A + \delta_m = i$ **(B)** $A + \delta_m = 2i$

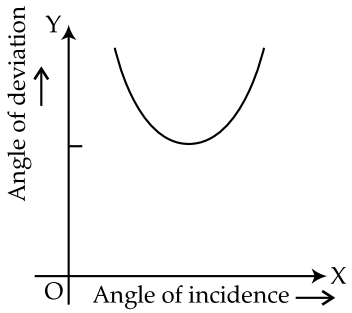
(C) $A + \delta_m/2 = i$ **(D)** $2A + \delta_m = i$

Ans. Option (B) is correct.

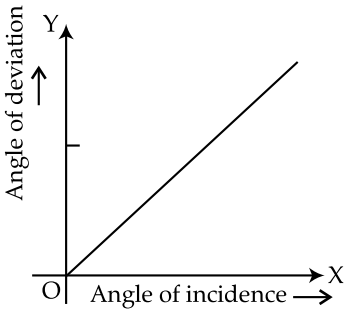
Explanation: For refraction through prism,
$i_1 + i_2 = \delta + A$ and $r_1 + r_2 = A$
For minimum deviation,
$i_1 = i_2 = i$ and $r_1 = r_2 = r$
So, $2i = (A + \delta_m)/2$
$\therefore A + \delta_m = 2i$

Q. 16. Which of the following graphs is the correct angle of incidence vs. angle of deviation graph?

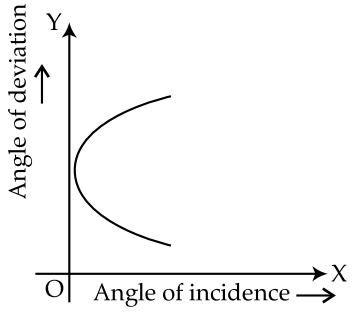
(A)



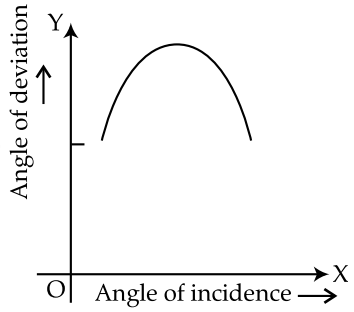
(B)



(C)



(D)



Ans. Option (A) is correct.

Q. 16. Magnifying power of a microscope depends on

(A) colour of light.

(B) focal length of objective and colour of light.

(C) focal length of eyepiece and colour of light.

(D) focal length of eyepiece and objective.

Ans. Option (D) is correct.

Explanation: Magnification $= m \propto 1/f_0 f_e$
So, magnifying power of a microscope depends on focal length of eyepiece and objective only.

Q. 17. Magnifying power of a telescope is

(A) $1/f_0 f_e$ **(B)** f_0/f_e

(C) f_e/f_0 **(D)** $f_0 f_e$

Ans. Option (B) is correct.

Q. 18. If m_1 and m_2 be the linear magnifications of the objective and eyepiece of a compound microscope, then the magnifying power of the compound microscope is

(A) $m_1 + m_2$ **(B)** $m_1 - m_2$

(C) $m_1 \times m_2$ **(D)** $(m_1 + m_2)/2$

Ans. Option (C) is correct.

Q. 19. In a compound microscope, image produced by objective is _____ and the image produced by eyepiece is _____.

(A) Real, real **(B)** Virtual, virtual

(C) Real, virtual **(D)** Virtual, real

Ans. Option (C) is correct.

Q. 20. Reflecting telescope utilises

(A) Convex mirror **(B)** Concave mirror

(C) Plane mirror **(D)** Prism

Ans. Option (B) is correct.

Q. 21. The magnifying power of a telescope is M. If the focal length of the eyepiece is halved, the magnifying power will become

(A) M/2 **(B)** 4M

(C) M/4 **(D)** None of the above

Ans. Option (D) is correct.

Explanation: Magnifying power is inversely proportional to the focal length of eyepiece. So, if focal length of the eyepiece is halved, the magnification will be 2M.

Q. 22. You are given the following 3 lenses. Two construct an astronomical telescope which one will you used as eyepiece and which one as objective?

Lens	Aperture (cm)	Power (D)
L1	8	3
L2	1	10
L3	1	6

(A) L1, L2 **(B)** L2, L1

(C) L2, L3 **(D)** L3, L1

Ans. Option (B) is correct.

> ***Explanation:*** The objective should have large aperture and large focal length while eyepiece should have small aperture and small focal length.

ASSERTION AND REASON BASED MCQs (1 Mark each)

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

Q. 1. Assertion (A): A convex mirror cannot form real images.

Reason (R): Convex mirror converges the parallel rays that are incident on it.

Ans. Option (C) is correct.

> ***Explanation:*** Convex mirror always form virtual image. So, the assertion is true.
> Parallel rays incident on convex mirror do not actually meet. They get reflected in such a manner that their extension meet at a point. So, the reason is false.

Q. 2. Assertion (A): The focal length of a concave mirror is f and an object is placed at a distance x from the focus. The magnification produced by the mirror is f/x.

Reason (R): magnification = size of image / size of object

Ans. Option (A) is correct.

> ***Explanation:*** $u = f+x$
> Using mirror formula,
> $1/v+1/u = 1/f$
> Or, $1/v - 1/(f+x) = -1/f$
> $\therefore\ v = -f(f+x)/x$
> Magnification (m) = size of image / size of object $= -v/u$
> $$|m| = \frac{f(f+x)}{x}\times\frac{1}{f+x} = f/x$$
> So, the assertion and reason both are true and the reason properly explains the assertion.

Q. 3. Assertion (A): The mirror formula $1/v + 1/u = 1/f$ is valid for mirrors of small aperture.

Reason (R): Laws of reflection of light is valid for only plane surface and not for large spherical surface.

Ans. Option (C) is correct.

> ***Explanation:*** The mirror formula is derived under the consideration that the incident rays are paraxial which means that the rays lie very close to the principal axis. Hence the mirror aperture is considered to be small. So, the assertion is true.
> Laws of reflection is valid for any surface plane or spherical. Hence the reason is false.

Q. 4. Assertion (A): Air bubbles shine in water.
Reason (R): Air bubbles shine in water due to refraction of light.

Ans. Option (A) is correct.

> ***Explanation:*** Air bubbles shine in water due to total internal reflection. Total internal reflection is a special case of refraction when light passes from denser medium (water) to rarer medium (air inside the bubble) and angle of incidence is more than the critical angle. So, the reason is also true. The reason also explains the assertion properly.

Q. 5. Assertion (A): A diamond of refractive index $\sqrt{6}$ is immersed in a liquid of refractive index $\sqrt{3}$. If light travels from diamond to liquid, total internal reflection will take place when angle of incidence is 30°.

Reason (R): $\mu = 1/\sin C$, where μ is the refractive index of diamond with respect to the liquid

Ans. Option (D) is correct.

> ***Explanation:*** Refractive index of diamond with respect to the liquid is $\sqrt{6}/\sqrt{3} = \sqrt{2}$
> So, critical angle for the diamond-liquid pair of media is $\sin^{-1}(1/\sqrt{2}) = 45°$.
> For total internal reflection, angle of incidence should be greater that critical angle.
> Since angle of incidence is 30°, total internal reflection cannot take place.
> So, the assertion is false. But the reason is true.

Q. 6. Assertion (A): A double convex air bubble is formed within a glass slab. The air bubble behaves like a converging lens.

Reason (R): Refractive index of glass is more that the refractive index of air.

Ans. Option (D) is correct.

Explanation: Speed of light is slower in glass compared to that in air. Hence the refractive index of glass is more than that of air. So the reason is true.
When a double convex air bubble is formed within a glass slab, the refractive index of the medium of the bubble is less than the refractive index of the surrounding medium. Hence the lens will not behave like a converging lens. It will behave like a diverging lens. So, the assertion is false.

Q. 7. Assertion (A): The scattering of light while passing through a true solution is called Tyndall effect.

Reason (R): Intensity of scattered light is inversely proportional to the fourth power of wavelength.

Ans. Option (D) is correct.

Explanation: When light is passed through a true solution does not occur. Scattering occurs when light is passed through a colloidal solution. So, the assertion is false.
In Rayleigh scattering intensity of scattered light is inversely proportional to the fourth power of wavelength, blue light is scattered mush more strongly than red light. Hence the reason is true.

Q. 8. Assertion (A): A convex lens of focal length 30 cm can't be used as a simple microscope in normal setting.

Reason (R): For normal setting, the angular magnification of simple microscope is $M = \frac{D}{f}$.

Ans. Option (B) is correct.

Explanation: For normal adjustment, a 30 cm lens final image cannot form image at the near point (25 cm from the eye). So the statement is true.
For image at infinity, angular magnification of simple microscope is given by $M = D/f$.
So, the reason is also true. But reason does not explain the assertion.

Q. 9. Assertion (A): If the objective lens and the eyepiece lens of a microscope are interchanged, it works as a telescope.

Reason (R): Objective lens of telescope require large focal length and eyepiece lens require small focal length.

Ans. Option (D) is correct.

Explanation: Magnification of microscope is inversely proportional to focal lengths of objective lens and the eyepiece lens. Hence both the focal lengths are small.
On the other hand, magnification of microscope is inversely proportional to focal lengths of eyepiece lens and directly proportional to the objective lens. So, focal length of objective lens is large and focal length of eyepiece lens is small.
Hence, if the objective lens and the eyepiece lens of a microscope are interchanged that will not meet the criterion of the telescope.
So, the reason is true. But the assertion is false.

Q. 10. Assertion (A): Convex lens behaves like a simple microscope.

Reason (R): For larger magnifying power, the focal length of convex lens should be small.

Ans. Option (A) is correct.

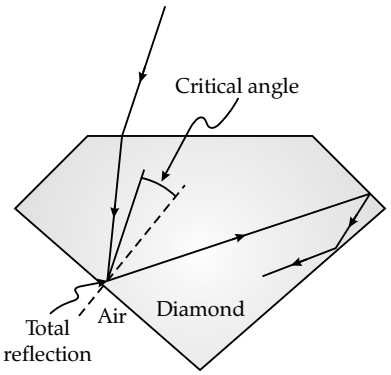
Explanation: Convex lens behaves like a simple microscope. The assertion is true.
The magnifying power of a convex lens is expressed as:
- For least distance of distinct vision, $m = 1 + \frac{D}{f}$
- For relaxed eye, $m = D/f$

Since f is in the denominator, for larger magnifying power, focal length should be small. So, the reason is also correct and it is the assertion.

CASE-BASED MCQs

Attempt any 4 sub-parts out of 5. Each sub-part carries 1 mark.

I. Read the following text and answer the following questions on the basis of the same:
Sparking Brilliance of Diamond:
The total internal reflection of the light is used in polishing diamonds to create a sparking brilliance. By polishing the diamond with specific cuts, it is adjusted the most of the light rays approaching the surface are incident with an angle of incidence more than critical angle. Hence, they suffer multiple reflections and ultimately come out of diamond from the top. This gives the diamond a sparking brilliance.



Q. 1. Light cannot easily escape a diamond without multiple internal reflections. This is because:

(A) its critical angle with reference to air is too large.

(B) its critical angle with reference to air is too small.

(C) the diamond is transparent.

(D) rays always enter at angle greater than critical angle.

Ans. Option (B) is correct.

> ***Explanation:*** Light cannot easily escape a diamond, because its critical angle with air is too small. Most of the reflections are total and it is cut so that light can exit only in particular direction —thus light is concentrated inside and making the diamond sparkle.

Q. 2. The critical angle for a diamond is 24.4°. Then its refractive index is:

(A) 2.42 **(B)** 0.413

(C) 1 **(D)** 1.413

Ans. Option (A) is correct.

> ***Explanation:*** Refractive index = 1/ sin C
> C = critical angle = 24.4
> $\therefore \mu = 1/\sin 24.4 = 1/0.4131 = 2.42$

Q. 3. The basic reason for the extraordinary sparkle of suitably cut diamond is that:

(A) it has low refractive index.

(B) it has high transparency.

(C) it has high refractive index.

(D) it is very hard.

Ans. Option (C) is correct.

> ***Explanation:*** The brilliance of diamond is due to its too small critical angle with air. As the critical angle become smaller, value of sine of critical angle also become small and hence refractive index increases (since $\mu = 1/\sin C$). So, the basic reason for the extraordinary sparkle of suitably cut diamond is its high refractive index.

Q. 4. A diamond is immersed in a liquid with a refractive index greater than water. Then the critical angle for total internal reflection will:

(A) depend on the nature of the liquid.

(B) decrease.

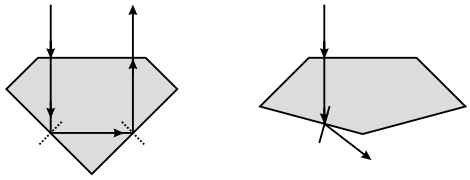
(C) remains the same.

(D) increase.

Ans. Option (D) is correct.

> ***Explanation:*** A diamond is immersed in a liquid with a refractive index greater than water. Then the critical angle for total internal reflection will increase.
> This is because, as the refractive index of outer medium increases, the refracted ray bends less away from normal. So, angle of incidence should increase more to achieve 90° angle of refraction.

Q. 5. The following diagram shows same diamond cut in two different shapes.



The brilliance of diamond in the second diamond will be:

(A) less than the first.

(B) greater than first.

(C) same as first.

(D) will depend on the intensity of light.

Ans. Option (A) is correct.

> ***Explanation:*** The brilliance of diamond in the second diamond will be less than the first since in the second case, no total internal reflection has taken place.

II. Read the following text and answer the following questions on the basis of the same:

Photometry:

The measurement of light as perceived by human eye is called photometry. Photometry is measurement of a physiological phenomenon, being the stimulus of light as received by the human eye, transmitted by the optic nerves and analysed by the brain. The main physical quantities in photometry are (i) the luminous intensity of the source, (ii) the luminous flux or flow of light from the source and (iii) illuminance of the surface. The SI unit of luminous intensity (I) is candela (cd). The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} Hz and that has a radiant intensity in that direction of 1/683 watt per steradian. If a light source emits one candela of luminous intensity into a solid angle of one steradian, the total luminous flux emitted into that solid angle is one lumen (lm). A standard 100 watt incandescent light bulb emits approximately 1700 lumens.

Q. 1. What is photometry?

(A) Measurement of light as perceived by human eye

(B) Measurement of number of photons emerging from a light source

(C) Measurement of electrons emitted by photosensitive surface

(D) Measurement of photosensitivity

Ans. Option (A) is correct.

> ***Explanation:*** The measurement of light as perceived by human eye is called photometry.

Q. 2. Light received by human eye is analysed by:

(A) retina **(B)** brain

(C) optic nerve **(D)** nervous system

Ans. Option (B) is correct.

> ***Explanation:*** Light received by the human eye, transmitted by the optic nerves and analysed by the brain.

Q. 3. The SI unit of luminous intensity is:

(A) Dioptre **(B)** Steradian

(C) Candela **(D)** Lumen

Ans. Option (C) is correct.

> ***Explanation:*** The SI unit of luminous intensity (I) is candela (cd).

Q. 4. Unit of luminous flux is:

(A) Candela **(B)** Steradian

(C) Nit **(D)** Lumen

Ans. Option (D) is correct.

> ***Explanation:*** The total luminous flux emitted into a solid angle is one lumen (lm).

Q. 5. A standard 100 watt incandescent light bulb emits approximately:

(A) 1700 Lumen **(B)** 700 Lumen

(C) 1200 Lumen **(D)** 1000 Lumen

Ans. Option (A) is correct.

> ***Explanation:*** A standard 100 watt incandescent light bulb emits approximately 1700 lumens.

III. Read the following text and answer the following questions on the basis of the same:

Optical Fibre:

Optical fibre works on the principle of total internal reflection. Light rays can be used to transmit a huge amount of data, but there is a problem here – the light rays travel in straight lines. So unless we have a long straight wire without any bends at all, harnessing this advantage will be very tedious. Instead, the optical cables are designed such that they bend all the light rays' inwards (using TIR). Light rays travel continuously, bouncing off the optical fibre walls and transmitting end to end data. It is usually made of plastic or glass.

Modes of transmission: Single-mode fibre is used for long-distance transmission, while multi-mode fiber is used for shorter distances. The outer cladding of these fibres needs better protection than metal wires. Although light signals do degrade over progressing distances due to absorption and scattering. Then, optical Regenerator system is necessary to boost the signal.

Types of Optical Fibres: The types of optical fibers depend on the refractive index, materials used, and mode of propagation of light. The classification based on the refractive index is as follows:

- Step Index Fibres: It consists of a core surrounded by the cladding, which has a single uniform index of refraction.
- Graded Index Fibres: The refractive index of the optical fibre decreases as the radial distance from the fibre axis increases.

Q. 1. Optical fibre works on the principle of:

(A) scattering of light.

(B) diffraction of light.

(C) total internal reflection of light.

(D) dispersion of light.

Ans. Option (C) is correct.

> ***Explanation:*** The optical fibre works on the principle of total internal reflection.

Q. 2. For long-distance transmission:

(A) single mode fibre is used.

(B) multi-mode fibre is used.

(C) both single mode and multi-mode are used.

(D) any one of single mode or multi-mode may be used.

Ans. Option (A) is correct.

> ***Explanation:*** Single-mode fibre is used for long-distance transmission, while multi-mode fibre is used for shorter distances.

Q. 3. Optical fibre is made of:

(A) copper **(B)** semiconductor

(C) plastic or glass **(D)** superconductors

Ans. Option (C) is correct.

> ***Explanation:*** Optical fibre is usually made of plastic or glass, so that light rays can travel continuously, bouncing off the optical fibre walls and can be transmitting end to end data.

Q. 4. In graded index optical fibre:

(A) the refractive index of the optical fibre increases as the radial distance from the fibre axis increases.

(B) the refractive index of the optical fibre decreases as the radial distance from the fibre axis increases.

(C) the refractive index of the optical fibre remains same throughout.

(D) inner side of cladding is mirrored to ensure reflection.

Ans. Option (B) is correct.

> ***Explanation:*** In graded index fibres, the refractive index of the optical fibre decreases as the radial distance from the fibre axis increases.

Q. 5. Light signal through optical fibre may degrade due to:

(A) refraction.

(B) refraction and reflection.

(C) diffraction and scattering.

(D) scattering and absorption.

Ans. Option (D) is correct.

> ***Explanation:*** Light signals do degrade over progressing distances due to absorption and scattering.

IV. Read the following text and answer the following questions on the basis of the same:

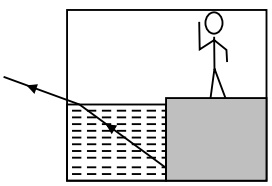
Negative Refractive Index:

One of the most fundamental phenomena in optics is refraction. When a beam of light crosses the interface between two different materials, its path is altered depending on the difference in the refractive indices of the materials. The greater the difference, the greater the refraction of the beam. For all known naturally occurring materials the refractive index assumes only positive values. But does this have to be the case?

In 1967, Soviet physicist Victor Veselago hypothesized that a material with a negative refractive index could exist without violating any of the laws of physics.

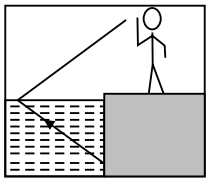
Veselago predicted that this remarkable material would exhibit a wide variety of new optical phenomena. However, until recently no one had found such a material and Veselago's ideas had remained untested. Recently, meta-material samples are being tested for negative refractive index. But the experiments show significant losses and this could be an intrinsic property of negative-index materials.

Snell's law is satisfied for the materials having a negative refractive index, but the direction of the refracted light ray is 'mirror-imaged' about the normal to the surface.



There will be an interesting difference in image formation if a vessel is filled with "negative water" having refractive index – 1.33 instead of regular water having refractive index 1.33.

Say, there is a fish in a vessel filled with negative water. The position of the fish is such that the observer cannot see it due to normal refraction since the refracted ray does not reach to his eye.



But due to negative refraction, he will be able to see it since the refracted ray now reaches his eye.

Q. 1. Who hypothesized that a material may have negative refractive index ?

(A) Joseph Von Fraunhofer

(B) Augustin-Jean Fresnel

(C) Thomas Moore

(D) Victor Veselago

Ans. Option (D) is correct.

> ***Explanation:*** In 1967, Soviet physicist Victor Veselago hypothesized that a material with a negative refractive index could exist without violating any of the laws of physics.

Q. 2. Is Snell's law applicable for negative refraction ?

(A) Yes

(B) No

(C) Unpredictable

(D) Yes, only for normal incidence

Ans. Option (A) is correct.

> ***Explanation:*** Snell's law is satisfied for the materials having a negative refractive index, but the direction of the refracted light ray is 'mirror-imaged' about the normal to the surface.

Q. 3. A ray in incident on normal glass and "negative glass" at an angle 60°. If the magnitude of angle of refraction in normal glass is 45° then, what will be the magnitude of angle of refraction in the "negative glass"?

(A) Less than 45° **(B)** More than 45°

(C) 45° **(D)** Unpredictable

Ans. Option (C) is correct.

> ***Explanation:*** The magnitude of angle of refraction in normal "negative glass" will also be 45°, but the direction of the refracted light ray is 'mirror-imaged' about the normal to the surface.

Q. 4. When the angle of incidence will be equal to angle of refraction for material having negative refraction index?

(A) When angle of incidence = 90°

(B) When angle of incidence = 0°

(C) It will vary from material to material

(D) It is never possible

Ans. Option (B) is correct.

> ***Explanation:*** Like normal refraction, for material having negative refraction index also when the angle of incidence is equal to 0°, then angle of refraction will be equal to angle of incidence *i.e.* 0°.

Q. 5. Which of the following is the intrinsic property of negative-index materials?

(A) Significant gain of light energy due to refraction

(B) No loss of light energy due to refraction

(C) Significant loss of light energy due to refraction

(D) Loss of energy due to refraction in intermittent

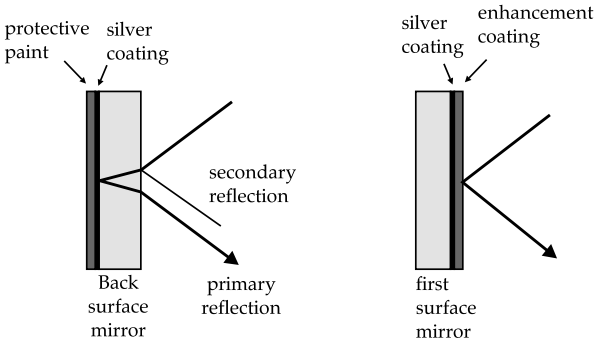
Ans. Option (C) is correct.

> ***Explanation:*** Recently, meta-material samples are being tested for negative refractive index. The experiments show significant losses and this is an intrinsic property of negative index materials.

V. Read the following text and answer the following questions on the basis of the same:

First Surface Mirror:

Normally we use back surface mirrors. These are considered low precision mirrors because they actually have two reflecting surfaces. The first reflecting surface is the initial surface on the pane of glass where a small percentage of light is reflected off the surface. The second reflecting surface is the aluminium coating where a high percentage of light is reflected off the surface.



This dual reflection effect of a low precision mirror causes a loss of contrast and image distortion that is undesirable in high precision applications like rear projection systems, scanners and reflecting telescopes. In these cases good image quality is highly preferred, and this is where a front surface mirror is desired for clarity and single image reflection. First surface mirrors are quite common in professional optics. However, compared with back surface mirrors, they have the important disadvantage of being substantially more sensitive. The front surface may be touched, and a metal coating on the front surface is substantially more sensitive than a bare glass surface. For example, fingerprints can easily cause oxidation of the metal.. Also, moisture or aggressive gases may cause oxidation of the mirror coating.

Q. 1. Precision of back surface mirrors is:

(A) high.

(B) low.

(C) depends on intensity of light.

(D) similar to first surface mirror.

Ans. Option (B) is correct.

> ***Explanation:*** Normally, we use back surface mirrors. These are considered low precision mirrors because they actually have two reflecting surfaces.

Q. 2. Light incident on back surface mirror suffers:

(A) two reflections.

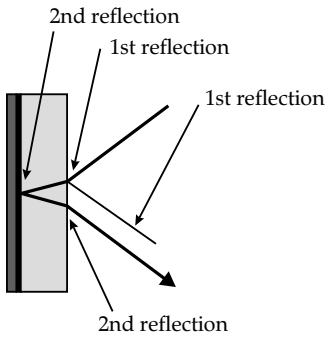
(B) one reflection.

(C) two reflections and two refractions.

(D) one refraction and one reflection.

Ans. Option (C) is correct.

> ***Explanation:*** This dual reflection and refraction effect of a low precision mirror causes a loss of contrast and image distortion.



Q. 3. In professional optics:

(A) first surface mirrors are used.

(B) back surface mirrors are used.

(C) both type of mirrors are used.

(D) mirrors are not used.

Ans. Option (A) is correct.

> ***Explanation:*** First surface mirrors are quite common in professional optics.

Q. 4. Image formed of front coated mirror:

(A) suffers astigmatism **(B)** is brilliant

(C) has low contrast **(D)** is a dual image

Ans. Option (C) is correct.

Explanation: Front surface mirror produces bright, distinct and distortion less image. No ghost image is formed.

Q. 5. The front surface coating:
(A) is susceptible to moisture.
(B) is not so sensitive.
(C) is worse than back surface coating.
(D) cannot prevent dual reflection.

Ans. Option (A) is correct.

Explanation: The front surface mirror is substantially more sensitive than a bare glass surface. For example, fingerprints can easily cause oxidation of the metal. Also, moisture or aggressive gases may cause oxidation of the mirror coating.

❐❐

CHAPTER 10

Term-II

WAVE OPTICS

Syllabus

- *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, coherent sources and sustained interference of light, diffraction due to a single slit, width of central maximum*

STAND ALONE MCQs (1 Mark each)

Q. 1. Wavefront generated from a line source is

(A) cylindrical wavefront

(B) spherical wavefront

(C) plane wavefront

(D) either (A) or (B)

Ans. Option (A) is correct.

Q. 2. Phase difference between any two points of a wavefront is

(A) π **(B)** $\pi/2$

(C) 0 **(D)** $\pi/4$

Ans. Option (C) is correct.

> ***Explanation:*** Wavefront is the locus of all points those are in same phase.

Q. 3. In Huygens theory, light waves

(A) are transverse waves and require a medium to travel.

(B) are longitudinal waves and require a medium to travel.

(C) are transverse waves and require no medium to travel.

(D) are longitudinal waves and require no medium to travel.

Ans. Option (B) is correct.

> ***Explanation:*** According to Huygens, light waves are longitudinal waves and require a material medium to travel. For this reason Huygens assumed the existence of a hypothetical medium called luminiferous ether.

Q. 4. Huygens theory could not explain

(A) photoelectric effect.

(B) reflection of light.

(C) diffraction of light.

(D) interference of light.

Ans. Option (A) is correct.

> ***Explanation:*** Wave nature of light cannot explain the photoelectric effect. Particle nature of light can only explain it.

Q. 5. Which of the following statement is true?

(A) According to both Maxwell's electromagnetic theory and Huygens wave theory light is treated as a wave in nature and require medium to travel.

(B) According to both Maxwell's electromagnetic theory and Huygens wave theory light is treated as a particle in nature and require medium to travel.

(C) According to both Maxwell's electromagnetic theory and Huygens wave theory light is treated as a wave in nature and does not require medium to travel.

(D) According to Maxwell's electromagnetic theory light is treated as a wave in nature and require no medium to travel. According to Huygens theory light is treated as a wave in nature and require medium to travel.

Ans. Option (D) is correct.

Q. 6. In a Young's double-slit experiment the source is white light. One of the holes is covered by a red filter and another by a blue filter. In this case,

(A) there shall be alternate interference patterns of red and blue.

(B) there shall be an interference pattern for red distinct from that for blue.

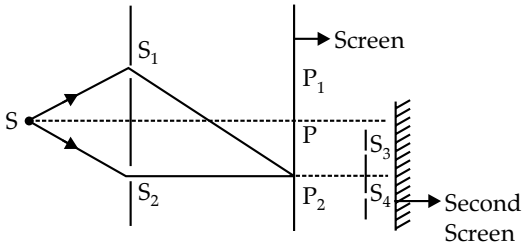
(C) there shall be no interference fringes.

(D) there shall be an interference pattern for red mixing with one for blue.

Ans. Option (C) is correct.

> ***Explanation:*** For sustained interference, the source must be coherent and should emit the light of same frequency.
> In this problem, one hole is covered with red and other with blue, which has different frequency, so no interference takes place.

Q. 7. Figure shows a standard two-slit arrangement with slits S_1, S_2. P_1, P_2 are the two minima points on either side of P shows in Figure. At P_2 on the screen, there is a hole and behind P_2 is a second screen, 2-slit arrangement with slits S_3 and S_4 and a second screen behind them.



(A) There would be no interference pattern on the second screen but it would be lighted.

(B) The second screen would be totally dark.

(C) There would be a single bright point on the second screen.

(D) There would be a regular two slit pattern on the second screen.

Ans. Option (D) is correct.

> ***Explanation:*** At P_2 is minima due to two wave fronts in opposite phase coming from, two slits S_1 and S_2, but there is wave fronts from S_1, S_2. So P_2 will act as a source of secondary wavelets. Wave front starting from P_2 reaches at S_3 and S_4 slits which will again act as two monochromatic or coherent sources and will form pattern on second screen.

Q. 8. In Young's double slit experiment, the distance between the slits is reduced to half and the distance between the slits and the screen is doubled. The fringe width

(A) will be double. **(B)** will be half.

(C) will remain same. **(D)** will be four times.

Ans. Option (D) is correct.

> ***Explanation:*** Fringe width = $\beta = \lambda D/d$
> Initially, $\beta = \lambda D/d$
> Finally, $\beta' = \dfrac{\lambda \times 2D}{d/2} = 4 \times \dfrac{\lambda D}{d} = 4\beta$

Q. 9. A Young's double slit experiment is performed with blue (wavelength 460 nm) and green light (wavelength 550 nm) respectively. If y is the distance of 4th maximum from the central fringe then

(A) $y_B = y_G$ **(B)** $y_B > y_G$

(C) $y_G > y_B$ **(D)** $y_B/y_G = 550/460$

Ans. Option (C) is correct.

> ***Explanation:*** $y_n = n\lambda D/d$
> So, $y_n \propto \lambda$
> Since $\lambda_G > \lambda_B$
> $\therefore$ $\phi_G > y_B$

Q. 10. A Young's Double slit experiment is performed in air and in water. Which of the following relationship is true regarding fringe width (β)?

(A) $\beta_{AIR} > \beta_{WATER}$ **(B)** $\beta_{WATER} > \beta_{AIR}$

(C) $\beta_{AIR} = \beta_{WATER}$ **(D)** $\beta_{WATER} = 0$

Ans. Option (A) is correct.

> ***Explantion:*** $\beta \propto \lambda$ and $\lambda \propto 1/\mu$
> So, $\beta \propto 1/\mu$
> Since $\mu_{WATER} > \mu_{AIR}$
> $\therefore$ $\beta_{AIR} > \beta_{WATER}$

Q. 11. The penetration of light into the region of geometrical shadow is known as

(A) interference of light.

(B) diffraction of light.

(C) refraction of light.

(D) polarisation of light.

Ans. Option (B) is correct.

Q. 12. Angular width of central maxima of a single slit diffraction pattern is independent of

(A) slit width

(B) frequency of the light used

(C) wavelength of the light used

(D) distance between slit and screen

Ans. Option (D) is correct.

Explanation: Angular width = $2\sin^{-1}\lambda/d$
So, it is independent of D (distance between slit and screen).

Q. 13. When a monochromatic light is passed around a file wire a diffraction pattern is observed. How the fringe width will change by increasing the diameter?

(A) Fringe width has no relation with the diameter of wire

(B) Increases

(C) Decreases

(D) Fringe width changes with change of wavelength only

Ans. Option (C) is correct.

Explanation: $\beta = \lambda D/d$, where d is the diameter of the wire. So, if the diameter increases, fringe with decreases.

Q. 14. The main condition for diffraction to be observed is

(A) size of obstacle should be comparable to the wavelength of the wave

(B) size of obstacle should be much larger than the wavelength of the wave

(C) size of obstacle should be much smaller than the wavelength of the wave

(D) for any size of obstacle

Ans. Option (A) is correct.

ASSERTION AND REASON BASED MCQs (1 Mark each)

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

Q. 1. Assertion (A): According to Huygens theory no back-ward wavefront is possible.
Reason (R): Amplitude of secondary wavelets is proportional to (1+ cos θ), where θ is the angle between the ray at the point of consideration and direction of secondary wavelet.

Ans. Option (A) is correct.

Explanation: According to Huygens theory each and every point on a wavefront is the source of secondary wavelets. Secondary wavelets do not proceed backward. So the assertion is true.
Kirchhoff's explained that amplitude of secondary wavelets is proportional to (1+ cos θ), where θ is the angle between the ray at the point of consideration and direction of secondary wavelets. In the backward direction θ = 180°; so 1 + cos θ = 0; so there secondary wavelets do not proceed backward.
Hence assertion and both are true and the reason properly explains the assertion.

Q. 2. Assertion (A): Wavefront emitted by a point source of light in an isotropic medium is spherical.

Reason (R): Isotropic medium has same refractive index in all directions.

Ans. Option (A) is correct.

Explanation: If a medium has same refractive index at every point in all directions, then the wavefrom obtained from a point source in such a medium is spherical since wave travels in all direction with same speed. Such a medium is known as isotropic medium. So, the assertion and reason both are true and the reason explain the assertion properly.

Q. 3. Assertion (A): When a light wave travels from rarer to denser medium, its speed decreases. Due to this reduction of speed the energy carried by the light wave reduces.

Reason (R): Energy of wave is proportional to the frequency.

Ans. Option (D) is correct.

Explanation: When a light wave travels from rarer to denser medium, its speed decreases. But this reduction of speed does not imply the loss of energy carried by the light wave. So the assertion is false.
Energy of wave is proportional to the frequency of the wave which remains same in very medium. Hence there is no loss of energy. So, the reason is true.

Q. 4. Assertion (A): No interference pattern is detected when two coherent sources are too close to each other.

Reason (R): The fringe width is inversely proportional to the distance between the two slits.

Ans. Option (A) is correct.

Explanation: No interference pattern is detected when two coherent sources are too close to each other. The assertion is true.
Fringe width is proportional to $1/d$. When d becomes too small, the fringe width becomes too large. So no pattern will be visible. So, the reason is also true. Reason also explains the assertion.

Q. 5. **Assertion (A):** For best contrast between maxima and minima in the interference pattern of Young's double slit experiment, the amplitudes of light waves emerging from the two sources should be equal.
Reason (R): For interference, the sources must be coherent.

Ans. **Option (B) is correct.**

Explanation: For destructive interference, $a = a_1 \sim a_2$. When $a_1 = a_2$, only the minima will be completely dark. This will create the best contrast. So the assertion is true.
For interference, the sources must be coherent. Reason is also true. But the reason does not explain the assertion.

Q. 6. **Assertion (A):** Fringes of interference pattern produced by blue light is narrower than that produced by red light.
Reason (R): In Young's double slit experiment, fringe width= $\lambda D/d$

Ans. **Option (C) is correct.**

Explanation: Fringes of interference pattern produced by blue light is narrower than that produced by red light. The assertion is true.
Fringe width = $\lambda D/d$. Since blue light has wavelength smaller than that of red light, blue light produces narrower fringes. So, reason is also true and explains the assertion.

Q. 7. **Assertion (A):** Diffraction takes place with all types of waves.
Reason (R): Diffraction is perceptible when the wavelength of the wave is comparable to the dimension of the diffracting device.

Ans. **Option (B) is correct.**

Explanation: Diffraction is spreading of waves around obstacle. It takes place with all types of waves (mechanical, non-mechanical, transverse, longitudinal) and with very small moving particles (atom, neutron, electron etc.) which show wave like property. So, the assertion is true.
Diffraction is perceptible when the wavelength of the wave is comparable to the dimension of the diffracting device. The reason is also true. But it does not explain the assertion.

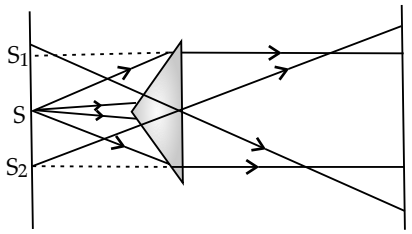
CASE-BASED MCQs

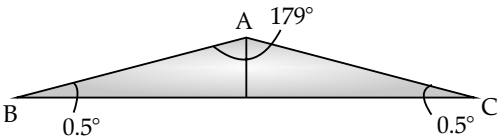
Attempt any 4 sub-parts out of 5. Each sub-part carries 1 mark.

I. Read the following text and answer the following questions on the basis of the same:

In one of his experiments on interference, August Jean Fresnel used a biprism to induce interference between two beams. He split a diverging beam of light into two parts by using the biprism to refract them. This resulted in two split beams which acted as if they were from two coherent sources and which therefore interfered with each other.

A Fresnel Biprism is a thin double prism placed base to base and have very small refracting angle (0.5°). This is equivalent to a single prism with one of its angle nearly 179° and other two of 0.5° each.





In Young's double Slits experiment, a single source is split in two coherent sources. For the Young's slits experiment, we must approximate that the slits act as point sources. This however is not the case, since the slits have finite width. In this way, it gives rise to unwanted diffraction effects that causes errors.

The Fresnel biprism experiment overcomes this problem.

A Fresnel biprism is a variation of Young's Slits experiment. When monochromatic light through a narrow slit falls on biprism that divides it into two components. One of these component is refracted from upper portion of biprism and the other one refracted through lower portion. Two virtual coherent sources formed from the original source. In this case, two virtual coherent sources are point sources and replace slits in Young's experiment.

Q. 1. The Fresnel biprism is:

(A) a combination of two prisms with their bases in contact.

(B) a combination of two prisms with their refracting surfaces in contact.

(C) single prism

(D) not a prism actually.

Ans. Option (A) is correct.

> ***Explanation:*** A Fresnel Biprism is a thin double prism placed base to base.

Q. 2. Base angles of Fresnel biprism are:

(A) 179° **(B)** 90°

(C) 0.50° **(D)** None of these

Ans. Option (C) is correct.

> ***Explanation:*** A Fresnel Biprism is a thin double prism placed base to base and have very small refracting angle (0.5°).

Q. 3. Fresnel biprism produces:

(A) two real coherent sources.

(B) two virtual coherent sources.

(C) a number of real coherent sources.

(D) a number of virtual coherent sources.

Ans. Option (A) is correct.

> ***Explanation:*** When monochromatic light through a narrow slit falls on Fresnel biprism that divides it into two components. One of these component is refracted from upper portion of biprism and the other one refracted through lower portion. Thus, two virtual coherent sources formed from the original source.

Q. 4. What is the difference between the coherent sources produced by Young's double slit arrangement and Fresnel biprism?

(A) Young's double slit arrangement produces virtual coherent sources whereas Fresnel biprism produces real coherent sources

(B) Young's double slit arrangement produces coherent point sources whereas Fresnel biprism produces coherent sources which are not point sources

(C) Both Young's double slit arrangement and Fresnel biprism produce similar coherent sources

(D) Fresnel birism produces virtual coherent point sources whereas Young's double slit arrangement produces real coherent sources which are not point sources.

Ans. Option (D) is correct.

> ***Explanation:*** In Young's double Slits experiment, a single source is split in two coherent sources. Both are real. Both the slits have finite width. Fresnel biprism divides the beam of monochromatic light incident on it into two components. One of these component is refracted from upper portion of biprism and the other one refracted through lower portion. Thus two virtual coherent sources are formed from the original source.

Q. 5. Which problem of Young's double slit experiment is overcome by Fresnel biprism?

(A) Young's double slit arrangement gives rise to irregular interference fringe pattern which is overcome by Fresnel biprism which produces coherent sources by refraction in a prism

(B) Finite width of slits in Young's double slit experiment gives rise to unwanted diffraction effects that causes errors. This is overcome by Fresnel biprism by producing virtual coherent point sources.

(C) Young's double slit arrangement produces interference fringe pattern of low intensity which is overcome by Fresnel biprism.

(D) All of the above

Ans. Option (B) is correct.

> ***Explanation:*** In Young's double Slits experiment, a single source is split in two coherent sources. For the Young's slits experiment, we must approximate that the slits act as point sources. This however is not the case, since the slits have finite width. In this way, it gives rise to unwanted diffraction effects that causes errors.
>
> The Fresnel biprism experiment overcomes this problem.
>
> When monochromatic light through a narrow slit falls on biprism that divides it into two components. One of these component is refracted from upper portion of biprism and the other one refracted through lower portion. Two virtual coherent point sources are formed from the original source.

II. Read the following text and answer the following questions on the basis of the same:

Diffraction in a hall:

A and B went to purchase a ticket of a music programme. But unfortunately only one ticket was left. They purchased the single ticket and decided that A would be in the hall during the 1st half and B during the 2nd half.

Both of them reached the hall together. A entered the hall and found that the seat was behind a pillar which creates an obstacle. He was disappointed. He thought that he would not be able to hear the programme properly.

B was waiting outside the closed door. The door was not fully closed. There was a little opening.

But surprisingly, A could hear the music programme.

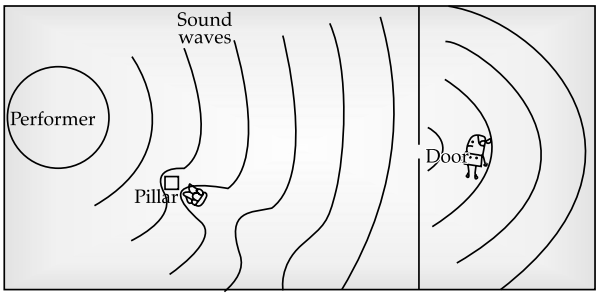
This happened due to diffraction of sound.

The fact we hear sounds around corners and around barriers involves both diffraction and reflection of sound.

Diffraction in such cases helps the sound to "bend around" the obstacles.

In fact, diffraction is more pronounced with longer wavelengths implies that we can hear low frequencies around obstacles better than high frequencies.

B was outside the door. He could also hear the programme. But he noticed that when the door opening is comparatively less he could hear the programme even being little away from the door. This is because when the width of the opening is larger than the wavelength of the wave passing through the gap then it does not spread out much on the other side. But when the opening is smaller than the wavelength more diffraction occurs and the waves spread out greatly – with semicircular wavefront. The opening in this case functions as a localized source of sound.



Q. 1. A and B could hear the music programme due to phenomenon named

(A) interference. **(B)** scattering.

(C) diffraction. **(D)** dispersion.

Ans. Option (C) is correct.

> ***Explanation:*** The fact we hear sounds around corners and around barriers involves both diffraction and reflection of sound.

Q. 2. Diffraction is more pronounced with _____ wavelengths.

(A) Longer **(B)** Shorter

(C) fluctuating **(D)** all

Ans. Option (A) is correct.

> ***Explanation:*** In fact, diffraction is more pronounced with longer wavelengths

Q. 3. The minimum and maximum frequencies in the musical programme were 550 Hz and 10 kHz. Which frequency was better audible around the pillar obstacle?

(A) 10 kHz

(B) 550 kHz

(C) Mid frequency

(D) The complete frequency range

Ans. Option (A) is correct.

> ***Explanation:*** In fact, diffraction is more pronounced with longer wavelengths implies that you can hear low frequencies around obstacles better than high frequencies.

Q. 4. Diffraction of sound takes place more when :

(A) sound is diffracted through an opening having width equal to the wavelength of the sound.

(B) sound is diffracted through an opening having width more than the wavelength of the sound.

(C) sound is diffracted through an opening having width less than the wavelength of the sound.

(D) diffraction of sound does not depend on the width of the opening.

Ans. Option (C) is correct.

> ***Explanation:*** When the width of opening is comparatively less than the wavelength of sound wave, the sound spread out much better i.e. better diffraction occurs.
>
> When the width of the opening is larger than the wavelength, the wave passing through the opening does not spread out much on the other side.

Q. 5. How the waveform will look like outside the door of the hall?

(A) Sound repeater

(B) Sound reflector

(C) Localized sound source

(D) None of the above

Ans. Option (C) is correct.

> ***Explanation:*** Sound spreads out well through a gap whose width is slightly smaller than the wavelength of the sound wave as if it is a localised source of sound.

❑❑

PART – VII : DUAL NATURE OF RADIATION AND MATTER

Term-II

CHAPTER 11

DUAL NATURE OF RADIATION AND MATTER

Syllabus

- *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*

STAND ALONE MCQs (1 Mark each)

Q. 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.

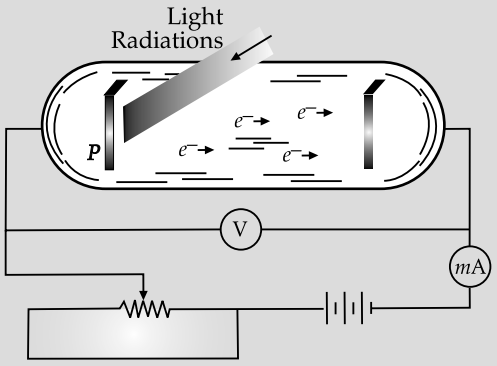
(B) electrons can be emitted but all with an energy, E_0.

(C) electrons can be emitted with any energy, with a maximum of $E_0 - \phi$ (ϕ is the work function).

(D) electron can be omitted with energy, with a maximum of E_0.

Ans. Option (D) is correct.

Explanation: If a beam of electrons of having energy E_0 is incident on a metal surface kept in an evacuated chamber.



The electrons can be emitted with maximum energy E_0 (due to elastic collision) and with any energy less than E_0, when part of incident energy of electron is used in liberating the electrons from the surface of metal.

Q. 2. The wavelength of a photon needed to remove a proton from a nucleus which is bound to the nucleus with 1 MeV energy is nearly

(A) 1.2 nm **(B)** 1.2×10^{-3} nm

(C) 1.2×10^{-6} nm **(D)** 1.2×10 nm

Ans. Optin (B) is correct.

Explanation: Energy of the photon must be equal to the binding energy of proton

So, energy of photon = 1 MeV

$= 10^6 \times 1.6 \times 10^{-19}$ J

$$\lambda = \frac{hc}{E} = \frac{6.63\times10^{-34}\times3\times10^{8}}{1.6\times10^{-13}} = \frac{6.63\times3}{1.60}\times10^{-26+13}$$

$$= \frac{19.89}{1.60}\times10^{-13} = 12.4\times10^{-13} = 1.24\times10^{1}\times10^{-13}$$

$$= 1.24\times10^{-9}\times10^{-3} = 1.24\times10^{-3} \text{ nm}$$

Q. 3. The phenomenon which shows quantum nature of electromagnetic radiation is:

(A) photoelectric effect.

(B) tyndall effect.

(C) interference.

(D) reflection and refraction.

Ans. Option (A) is correct.

Q. 4. Kinetic energy of electrons emitted in photoelectric effect is

(A) directly proportional to the intensity of incident light.

(B) inversely proportional to the intensity of incident line.

(C) independent of the intensity of incident light.

(D) independent of the frequency of light.

Ans. Option (C) is correct.

Explanation: KE = $h\nu - \phi$
So, KE is independent of intensity of incident light.

Q. 5. Threshold wavelength of a photoelectric emission from a material is 600 nm. Which of the following illuminating source will emit photoelectrons?

(A) 400 W, infrared lamp

(B) 10 W, ultraviolet lamp

(C) 100 W, ultraviolet lamp

(D) Both (B) & (C)

Ans. Option (D) is correct.

Explanation: The incident wavelength should be less than threshold wavelength for photoelectric emission. IR has wavelength more than 600 nm. UV has wavelength less than 600 nm. So, photoelectrons emitted when illuminated by UV lamp either 100 W or 10 W.

Q. 6. Photoelectrons emitted from a metal have

(A) different speeds starting from 0 to certain maximum.

(B) same kinetic energy.

(C) same frequency.

(D) Both (B) & (C)

Ans. Option (A) is correct.

Explanation: When a photon strikes a metal surface, the surface electrons come out with maximum speed and maximum kinetic energy. But if the electron emission takes place from inner side of metal, then some energy of the electron is lost due to collision with other electrons and so their speed becomes less. So, ultimately the electrons come out with different speeds.

Q. 7. At stopping potential, the kinetic energy of emitted photoelectron is

(A) minimum. **(B)** maximum.

(C) zero. **(D)** cannot de predicted

Ans. Option (C) is correct.

Q. 8. Photons are

(A) electrically neutral and not deflected by electric or magnetic field.

(B) electrically neutral and deflected by magnetic field.

(C) electrically charged and not deflected by electric or magnetic field.

(D) electrically charged and not deflected by electric field.

Ans. Option (A) is correct.

Q. 9. A particle is dropped from a height H. The de-Broglie wavelength of the particle as a function of height is proportional to

(A) H **(B)** $H^{1/2}$

(C) H^0 **(D)** $H^{-1/2}$

Ans. Option (D) is correct.

Explanation: Velocity v, of freely falling body after falling from a height H, will be :

$$H = v = \sqrt{2gH}$$

We know that de-Broglie wavelength, $\lambda = \frac{h}{p}$

$$\lambda = \frac{h}{mv} = \frac{h}{m\sqrt{2gH}}$$

h, m, and g are constant

$$\therefore \frac{h}{m\sqrt{2g}} \text{ is constant} \Rightarrow \lambda \propto \frac{1}{\sqrt{H}} \Rightarrow \lambda \propto H^{-1/2}$$

Q. 10. A proton, a neutron, an electron and an α-particle have same energy. Then, their de-Broglie wavelengths compare as

(A) $\lambda_p = \lambda_n > \lambda_e > \lambda_\alpha$ **(B)** $\lambda_\alpha < \lambda_p = \lambda_n > \lambda_e$

(C) $\lambda_e < \lambda_p = \lambda_n > \lambda_\alpha$ **(D)** $\lambda_e = \lambda_p = \lambda_n = \lambda_\alpha$

Ans. Option (B) is correct.

Explanation: Matter waves (de-Broglie waves) According to de-Broglie, a moving material particle sometimes acts as a wave and sometimes as a particle.

De- Broglie wavelength: $\lambda_d = \frac{h}{p}$

$$E_p = E_n = E_e = E_x$$

$$K.E. = K = \frac{1}{2}mv^2$$

$$2K = mv^2$$

$$2Km = m^2v^2$$

$$2mK = p^2$$

$$\sqrt{2mK} = p$$

$$\therefore \quad \lambda_d = \frac{h}{p}$$

$$\lambda_d = \frac{h}{\sqrt{2mK}}$$

or $\lambda_d = \frac{h}{\sqrt{2mK}}$ [as h and E (K.E.) is constt.]

$$\therefore \lambda \propto \frac{1}{\sqrt{m}}$$

$$m_a > m_p = m_n > m_e$$

$$\therefore \lambda_a < \lambda_p = \lambda_n < \lambda_e$$

Q. 11. An electron is moving with an initial velocity $v = v_o\hat{i}$ and is in a magnetic field $B = B_o\hat{j}$. Then, its de-Broglie wavelength

(A) remains constant.

(B) increases with time.

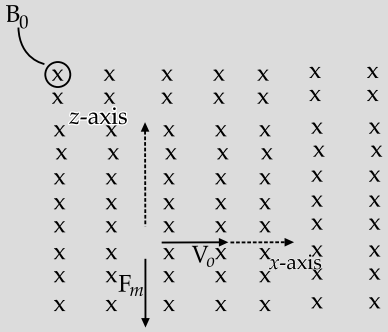
(C) decreases with time.

(D) increases and decreases periodically.

Ans. Option (A) is correct.

Explanation: Given, $v = v_o\hat{i}$ and $B = B_o\hat{j}$

Magnetic force on moving electron $= -e[v_o i \times B_o j] = -ev_oB_ok$



So, the force is perpendicular to v and B both as the force is perpendicular to the velocity. So, the magnitude will not change v or mv (p = mv momentum) so, the de-Broglie wavelength remains same.

Q. 12. An electron (mass m) with an initial velocity v v i ($v_0 > 0$) is in an electric field $E = -E_0\hat{i}$ (E_0= constant > 0). Its de-Broglie wavelength at time t is given by

(A) $\dfrac{\lambda_0}{\left[1+\dfrac{eE_0}{m}\dfrac{t}{v_0}\right]}$ **(B)** $\lambda_0\left[1+\dfrac{eE_0t}{mv_0}\right]$

(C) λ_0 **(D)** $\lambda_0 t$

Ans. Option (A) is correct.

Explanation: The wave associated with moving particle is called matter wave or de-Broglie wave and it propagates in the form of wave packets with group velocity. According to de-Broglie theory, the wavelength of de-Broglie wave is given by

$$\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\sqrt{2mE}}$$

As initial velocity of the electron is $v_0\hat{i}$, the initial de-Broglie wavelength of electron,

$$\lambda = \frac{h}{mv_0} \qquad ...(i)$$

Electrostatic force on electron in electric field is,

$$\vec{F}_e = -e\vec{E} = -e\left[-E_0\hat{i}\right] = eEz_0\hat{i}$$

Acceleration of electron, $\vec{a} = \dfrac{\vec{F}}{m} = \dfrac{eE_0\hat{j}}{m}$

Velocity of the electron after time t,

$$\vec{v} = v_0\hat{i} + \left(\frac{eE_0\hat{i}}{m}\right)t = \left(v_0 + \frac{eE_0}{m}t\right)\hat{i}$$

$$\Rightarrow \qquad \vec{v} = v_0\left(1 + \frac{eE_0}{mv_0}\right)\hat{i}$$

de-Broglie wavelength associated with electron at time t *is* $\lambda = \dfrac{h}{mv}$

$$\Rightarrow \qquad \lambda = \frac{h}{m\left[v_0\left(1+\dfrac{eE_0}{mv_0}t\right)\right]} = \frac{\dfrac{h}{mv_0}}{\left(1+\dfrac{eE_0}{mv_0}t\right)}$$

$$\Rightarrow \qquad \lambda = \frac{\lambda_0}{\left[1+\dfrac{eE_0}{mv_0}t\right]} \text{ As } \lambda_0 = \frac{h}{mv_0}$$

Q. 13. An electron (mass m) with an initial velocity $v = v_0\hat{i}$ is in an electric field $E = E_0\hat{j}$. If $\lambda_0 = \dfrac{h}{mv_0}$, its de-Broglie wavelength at time t is given by

(A) λ_0 **(B)** $\lambda_0\sqrt{1+\dfrac{e^2E_0^2t^2}{m^2v_0^2}}$

(C) $\dfrac{\lambda_0}{\sqrt{1+\dfrac{e^2E_0^2t^2}{m^2v_0^2}}}$ **(D)** $\dfrac{\lambda_0}{\left(1+\dfrac{e^2E_0^2t^2}{m^2v_0^2}\right)}$

Ans. Option (C) is correct.

Explanation: According to the problem de-Broglie wavelength of electron at time $t = 0$ is

$$\lambda_0 = \frac{h}{mv_0}$$

Electrostatic force on electron in electric field is

$$\vec{F}_e = -e\vec{E} = -eE_0\hat{j}$$

The acceleration of electron, $\vec{a} = \dfrac{\vec{F}}{m} = -\dfrac{eE_0}{m}\hat{j}$

It is acting along negative y-axis.

The initial velocity of electron along x-axis,

$$v_{x_0} = v_o\hat{i}$$

This component of velocity will remain constant as there is no force on electron in this direction. Now considering y-direction, initial velocity of electron along y-axis, $v_{y0} = 0$

Velocity of electron after time t along y-axis

$$v_y = 0 + \left(-\frac{eE_0}{m}J\right)t = -\frac{eE_0}{m}t\hat{j}$$

Magnitude of velocity of electron after time t is

$$v = \sqrt{v_x^2 + v_y^2} = \sqrt{v_0^2 + \left(\frac{-eE_0}{m}t\right)^2}$$

$$\Rightarrow \quad = v_0\sqrt{1 + \frac{e^2E_0^2t^2}{m^2v_0^2}}$$

de-Broglie wavelength, $\lambda_0 = \frac{h}{mv_0}$

$$= \frac{h}{mv_0\sqrt{1 + \frac{e^2E_0^2t^2}{m^2v_0^2}}} = \frac{\lambda_0}{\sqrt{1 + \frac{e^2E_0^2t^2}{m^2v_0^2}}}$$

$$\Rightarrow \quad \lambda' = \frac{\lambda_0}{\left(1 + \frac{e^2E_0^2t^2}{m^2v_0^2}\right)}$$

Q. 14. The ratio of de-Broglie wavelength associated with two electrons accelerated through 25 V and 36 V is

(A) 25/36 **(B)** 36/25

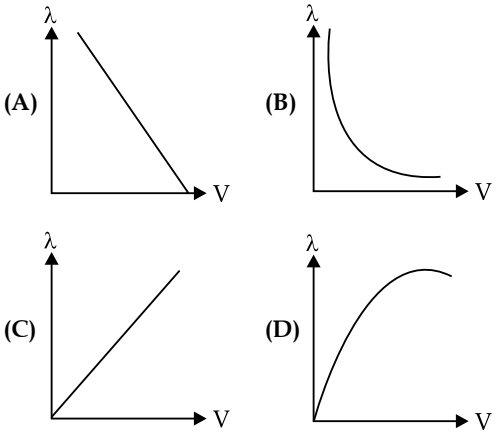
(C) 5/6 **(D)** 6/5

Ans. Option (D) is correct.

Explanation: $\lambda \propto 1/\sqrt{V}$

$\therefore \lambda_1/\lambda_2 = \sqrt{(V_2/V_1)} = 6/5$

Q. 15. Which of the following graphs shows the variation of de-Broglie wavelength with potential through which a particle of charge q and mass m is accelerated?



Ans. Option (B) is correct.

ASSERTION AND REASON BASED MCQs (1 Mark each)

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

Q. 1. **Assertion (A):** The energy (E) and momentum (p) of a photon are related as $p = E/c$

Reason (R): The photon behaves like a particle.

Ans. Option (A) is correct.

Explanation: Energy = E = hc/λ

Momentum = P = h/λ.

So, P = E/c

This is true only when photon has a particle nature.

So, assertion and reason both are true and reason properly explains the assertion.

Q. 2. **Assertion (A):** Photoelectric effect demonstrates the particle nature of light.

Reason (R): The number of photoelectrons is proportional to the frequency of light.

Ans. Option (C) is correct.

Explanation: Photoelectric effect demonstrates the particle nature of light. So assertion is true.

Number of emitted photoelectrons depends upon the intensity of light. So reason is false.

Q. 3. **Assertion (A):** Kinetic energy of photoelectrons emitted by a photosensitive surface depends upon the frequency of incident photon.

Reason (R): The ejection of electrons from metallic surface is possible with frequency of incident photon below the threshold frequency.

Ans. Option (C) is correct.

Explanation: K.E. depends upon the frequency. So assertion is true.

Photoelectron emitted when frequency of incident radiation is more than the threshold frequency. So reason is also false.

Q. 4. **Assertion (A):** Photosensitivity of a material is high if its work function is low.

Reason (R): Work function = hf_0, where f_0 is threshold frequency.

Ans. Option (B) is correct.

Explanation: Work function is less means less energy is required to eject photoelectrons. So, if the work function is less photosensitivity is high. So the assertion is true.
Work function is the minimum energy required to eject a photoelectron and Work function $= hf_0$, where f_0 is threshold frequency. So reason is also true but it does not explain the assertion.

Q. 5. **Assertion (A):** de-Broglie equation is significant for microscopic particles.
Reason (R): de-Broglie wavelength is inversely proportional to the mass of a particle when velocity is kept constant.

Ans. Option (A) is correct.

Explanation: de-Broglie wavelength, $\lambda = h/mv$
h and v remaining constant, $\lambda \propto 1/m$
So, as the mass of the particle becomes smaller and smaller the de-Broglie wavelength of the particle becomes more and more significant.
Hence, assertion and reason both are true and reason explains the assertion properly.

Q. 6. **Assertion (A):** de-Broglie wavelength of a gas molecule is inversely proportional to the square root of temperature.
Reason (R): The root mean square velocity of gas molecules depends on temperature.

Ans. Option (A) is correct.

Explanation: $v_{RMS} = \sqrt{\frac{3RT}{M}}$
So, $v_{RMS} \propto \sqrt{T}$
Again de-Broglie wavelength, $\lambda = h/mv$
So, $\lambda \propto 1/\sqrt{T}$
Hence, assertion and reason both are true and reason explains the assertion.

Q. 7. **Assertion (A):** Resolving power of electron microscope increases as electron is accelerated through higher voltage.
Reason (R): de-Broglie wavelength of electron decreases as accelerating voltage of electron increases.

Ans. Option (A) is correct.

Explanation: de-Broglie wavelength is given by $\lambda = \frac{h}{\sqrt{2meV}}$
So, as accelerating potential (V) increases, the wavelength decreases.
Resolving power of microscope $= \frac{2\mu sin\beta}{1.22\lambda}$
So, as wavelength (λ) decreases, resolving power increases.
So, assertion and reason both are true and reason explains the assertion.

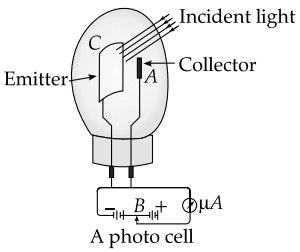
CASE-BASED MCQs

Attempt any 4 sub-parts out of 5. Each sub-part carries 1 mark.

I. Read the following text and answer the following questions on the basis of the same:

Photocell:

A photocell is a technological application of the photoelectric effect. It is a device whose electrical properties are affected by light. It is also sometimes called an electric eye. A photocell consists of a semi-cylindrical photo-sensitive metal plate C (emitter) and a wire loop A (collector) supported in an evacuated glass or quartz bulb. It is connected to the external circuit having a high-tension battery B and micro ammeter (μA) as shown in the Figure.



A photo cell

Sometimes, instead of the plate C, a thin layer of photosensitive material is pasted on the inside of the bulb. A part of the bulb is left clean for the light to enter it. When light of suitable wavelength falls on the emitter C, photoelectrons are emitted. These photoelectrons are drawn to the collector A. Photocurrent of the order of a few microampere can be normally obtained from a photo cell. A photocell converts a change in intensity of illumination into a change in photocurrent. This current can be used to operate control systems and in light measuring devices.

Q. 1. Photocell is an application of
(A) thermoelectric effect.
(B) photoelectric effect.
(C) photoresistive effect.
(D) None of the above

Ans. Option (B) is correct.

Explanation: Photocell is a technological application of the photoelectric effect

Q. 2. Photosensitive material should be connected to

(A) –ve terminal of the battery.

(B) +ve terminal of the battery.

(C) any one of (A) or (B).

(D) connected to ground.

Ans. Option (A) is correct.

> ***Explanation:*** Photosensitive material used as emitter should be connected to -ve terminal of the battery so that the emitted electrons are repelled by emitter and collected by collector.

Q. 3. Which of the following statement is true?

(A) The photocell is totally painted black.

(B) A part of the photocell is left clean.

(C) The photocell is completely transparent.

(D) A part of the photocell is made black.

Ans. Option (B) is correct.

> ***Explanation:*** A part of the bulb is left clean for the light to enter in it.

Q. 4. The photocurrent generated is in the order of

(A) ampere

(B) milliampere

(C) microampere

(D) None of the above

Ans. Option (C) is correct.

> ***Explanation:*** Photocurrent of the order of a few microampere can be normally obtained from a photocell.

Q. 5. A photocell converts a change in ___ of incident light into a change in ____ _

(A) intensity, photovoltage

(B) wavelength, photovoltage

(C) frequency, photocurrent

(D) intensity, photocurrent

Ans. Option (D) is correct.

> ***Explanation:*** A photocell converts a change in intensity of illumination into a change in photocurrent.

II. Read the following text and answer the following questions on the basis of the same:

Electron Microscope

Electron microscopes use electrons to illuminate a sample. In Transmission Electron Microscopy (TEM), electrons pass through the sample and illuminate film or a digital camera.

Resolution in microscopy is limited to about half of the wavelength of the illumination source used to image the sample. Using visible light the best resolution that can be achieved by microscopes is about ~200 nm. Louis de Broglie showed that every particle or matter propagates like a wave. The wavelength of propagating electrons at a given accelerating voltage can be determined by

$$l = \frac{h}{\sqrt{2m_e v}}.$$

Thus, the wavelength of electrons is calculated to be 3.88 pm when the microscope is operated at

100 keV, 2. 74 pm at 200 keV and 2.24 pm at 300 keV. However, because the velocities of electrons in an electron microscope reach about 70% the speed of light with an accelerating voltage of 200 keV, there are relativistic effects on these electrons. Due to this effect, the wavelength at 100 keV, 200 keV and 300 keV in electron microscopes is 3.70 pm, 2.51 pm and 1.96 pm, respectively.

Anyhow, the wavelength of electrons is much smaller than that of photons (2.5 pm at 200 keV). Thus if electron wave is used to illuminate the sample, the resolution of an electron microscope theoretically becomes unlimited. Practically, the resolution is limited to ~0.1 nm due to the objective lens system in electron microscopes. Thus, electron microscopy can resolve subcellular structures that could not be visualized using standard fluorescences microscopy.

Q. 1. In electron microscope, electron is used:

(A) to charge the sample.

(B) to clean the sample.

(C) to illuminate the sample.

(D) All of the above

Ans. Option (C) is correct.

> ***Explanation:*** Electrons as wave is used in electron microscopes to illuminate a sample since it enhances the resolving power.

Q. 2. Who showed that electron also propagates like a wave?

(A) Louis de Broglie

(B) Albert Einstein

(C) Philipp Lenard

(D) Wilhelm Ludwig Franz Hallwachs

Ans. Option (A) is correct.

> ***Explanation:*** Louis de Broglie showed that every particle or matter propagates like a wave.

Q. 3. Why electron as wave is used in electron microscope to illuminate the sample?

(A) The wavelength of electrons as wave is much larger than that of photons, hence resolution is much better.

(B) The wavelength of electrons as wave is much smaller than that of photons, hence resolution is much better.

(C) Electron as wave wave is much brighter than normal light and hence resolution is much better.

(D) Speed of electron as wave wave is greater than the speed of light and hence offers better resolution.

Ans. Option (B) is correct.

Explanation: Using visible light, the best resolution that can be achieved by microscopes is about ~200 nm. The wavelength of electrons as wave is much smaller than that of photons as wave (2.5 pm at 200 keV). Thus if electron as wave is used to illuminate the sample, the resolution of an electron microscope theoretically becomes unlimited. Practically, the resolution is limited to ~0.1 nm,

Q. 4. As the accelerating voltage increases, the wavelength of electron as wave

(A) decreases.

(B) increases.

(C) remains same.

(D) upto 100 keV increases and then decreases.

Ans. Option (A) is correct.

Explanation: $\lambda = \frac{h}{\sqrt{2meV}}$

So, as V increases, λ decreases.

Q. 5. Wavelength of electron as wave at accelerating voltage 200 keV is

(A) 2.5 nm **(B)** 2.5 mm

(C) 2.5 pm **(D)** 2.5 μm

Ans. Option (C) is correct.

❑❑

PART – VIII : ATOMS & NUCLEI

CHAPTER 12

Term-II

ATOMS

Syllabus

- *Alpha-particle scattering experiment; Rutherford's model of atom; Bohr model, energy levels, hydrogen spectrum.*

STAND ALONE MCQs (1 Mark each)

Q. 1. O_2 molecule consists of two oxygen atoms. In the molecule, nuclear force between the nuclei of the two atoms

(A) is not important because nuclear forces are short-ranged.

(B) is as important as electrostatic force for binding the two atoms.

(C) cancels the repulsive electrostatic force between the nuclei.

(D) is not important because oxygen nucleus have equal number of neutrons and protons.

Ans. Option (A) is correct.

Explanation: As we know that the nuclear forces is too much stronger. Only attractive force as compared to electrostatic repulsive force and nuclear force decreases to zero on increasing distance.
So in case of oxygen molecule, the distance between atoms of oxygen is larger as compared to the distances between nucleons in a nucleus. So that, the force between the nuclei of two oxygen atoms is not important as nuclear forces are short-ranged forces.

Q. 2. A set of atoms in an excited state decays.

(A) in general, to any of the states with lower energy.

(B) into a lower state only when excited by an external electric field.

(C) all together simultaneously into a lower state.

(D) to emit photons only when they collide.

Ans. Option (A) is correct.

Explanation: A set of atoms in an excited state decays in general to any of the states with lower energy.

Q. 3. Two H atoms in the ground state collide inelastically. The maximum amount by which their combined kinetic energy is reduced, is

(A) 10.20 eV. **(B)** 20.40 eV.
(C) 13.6 eV. **(D)** 27.2 eV.

Ans. Option (A) is correct.

Explanation: Total energy of two H-atom in ground state = $2(-13.6) = -27.2$ eV.
The maximum amount by which their combined kinetic energy is reduced when any one H-atom goes into first excited state after the inelastic collision, that is, the total energy of two H-atom after inelastic collision :

$$E = \frac{13.6}{n^2} + 13.6$$

$$= \frac{13.6}{2^2} + 13.61 \text{ [For excited state } (n = 2)]$$

$$= 3.4 + 13.6 = 17.0 \text{ eV}$$

So that the loss in kinetic energy due to inelastic collision will be,

$$= 27.2 - 17.0 = 10.2 \text{ eV}$$

Q. 4. Taking the Bohr radius as $a_0 = 53$ pm, the radius of Li^{++} ion in its ground state, on the basis of Bohr's model, will be about

(A) 53 pm. **(B)** 27 pm.
(C) 18 pm. **(D)** 13 pm.

Ans. Option (C) is correct.

Explanation: According to **Bohr's model of an atom**, radius of an atom in its ground state is

$r = \frac{r_0}{Z}$

where, r_0 is Bohr's radius and Z is atomic number.

As given that,

r_0 = 53 pm and atomic number of Lithium atom is 3

so, $r = \frac{53}{3} = 17.67 \text{ pm} \approx 18 \text{ pm}$

Q. 5. The binding energy of a H-atom, considering an electron moving around a fixed nuclei (proton), is $B = -\frac{me^4}{8n^2\varepsilon_0^2h^2}$ (m = electron mass). If one decides to work in a frame of reference where the electron is at rest, the proton would be moving around it. By similar arguments, the binding energy would be

$B = -\frac{Me^4}{8n^2\varepsilon_0^2h^2}$ (M = proton mass) .

This last expression is not correct because

(A) n would not be integral.

(B) Bohr-quantisation applies only to electron

(C) the frame in which the electron is at rest is not inertial.

(D) the motion of the proton would not be in circular orbits, even approximately.

Ans. Option (C) is correct.

Explanation: In a hydrogen atom, electrons revolving around a fixed proton nucleus have some centripetal acceleration. So that, its frame of reference is non-inertial. In the frame of reference, where the electron is at rest, the given expression is not true as it forms the non-inertial frame of reference.

As the mass of an electron is negligible as compared to proton, so the centripetal force cannot provide the electrostatic force,

$F_p = \frac{m_p v^2}{r}$

So the given expression is not true, as it forms non-inertial frame of reference due to $m_e <<< m_p$ or centripetal force on $F_e <<< F_p$.

Q. 6. The simple Bohr model cannot be directly applied to calculate the energy levels of an atom with many electrons. This is because

(A) of the electrons not being subject to a central force.

(B) of the electrons colliding with each other.

(C) of screening effects.

(D) the force between the nucleus and an electron will no longer be given by Coulomb's law.

Ans. Option (A) is correct.

Explanation: The simple Bohr model cannot be directly applied to calculate the energy levels of an atom with many electrons because when we derive the formula for radius/energy levels, etc., we make the assumption that centripetal force is provided only by electrostatic force of attraction by the nucleus.

So that, this will only work for single electron atoms. In multi-electron atoms, there will also be repulsion due to other electrons. The simple Bohr model cannot be directly applied to calculate the energy levels of an atom with many electrons.

Q. 7. For the ground state, the electron in the H-atom has an angular momentum = h, according to the simple Bohr model. Angular momentum is a vector and hence there will be infinitely many orbits with the vector pointing in all possible directions. In actuality, this is not true,

(A) because Bohr model gives incorrect values of angular momentum.

(B) because only one of these would have a minimum energy.

(C) angular momentum must be in the direction of spin of electron.

(D) because electrons go around only in horizontal orbits.

Ans. Option (A) is correct.

Explanation: According to Bohr's second postulate of atomic model, angular momentum of revolving electron must be some integral multiple of $\frac{h}{2\pi}$. So the Bohr's model of atom does not give correct value of angular momentum.

Q. 8. Choose the correct alternative from the clues given at the end of each statement :

(A) The size of the atom in Thomson's model is ..... the atomic size in Rutherford's model. (much greater than/no different from/much less than)

(B) In the ground state of ....., electrons are in stable equilibrium, while in ..... electrons always experience a net force. (Thomson's model/Rutherford's model)

(C) A classical atom based on ..... is doomed to collapse. (Thomson's model/Rutherford's model)

(D) An atom has a nearly continuous mass distribution in ..... but has a highly non-uniform mass distribution in ..... . (Thomson's model/Rutherford's model)

(E) The positively charged part of the atom possesses most of the mass in ..... . (Rutherford's model/both the models)

Ans. Option (D) is correct.

Explanation: (A) The sizes of the atoms taken in Thomson's model is not different from the atomic size in Rutherford's model.
(B) In the ground state of Thomson's model, the electrons are in stable equilibrium, while in Rutherford's model, electrons always experience a net force.
(C) A classical atom based on Rutherford's model is doomed to collapse.
(D) An atom has a nearly continuous mass distribution in Thomson's model, but has a highly non-uniform mass distribution in Rutherford's model.
(E) The positively charged part of the atom possesses most of the mass in both the models.

ASSERTION AND REASON BASED MCQs (1 Mark each)

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

Q. 1. Assertion (A): Bohr postulated that the electrons in stationary orbits around the nucleus do not radiate.
Reason (R): According to classical Physics, all moving electrons radiate.

Ans. Option (B) is correct.

Explanation: Bohr postulated that electrons in stationary orbits around the nucleus do not radiate. This is true.
According to classical Physics, the moving electrons radiate only when they jump from a higher energy orbit to the lower energy orbit. So, the reason is false.

Q. 2. Assertion (A): According to Rutherford, atomic model, the path of electron is parabolic.
Reason (R): Rutherford could not explain the stability of atom.

Ans. Option (D) is correct.

Explanation: According to Rutherford, "the entire positive charge and most of the mass of the atom is concentrated in a small volume called the nucleus, with electrons revolving around the nucleus just as planets revolve around the Sun."
So the assertion is false.
The electron orbiting around the nucleus radiate energy. As a result, the radius of the orbit continuously decreases and the electron fall into the nucleus. So, stability of atom is not explained. Hence the reason is true.

Q. 3. Assertion (A): In the α-particle scattering experiment, most of the α-particles pass undeviated.
Reason (R): Most of the space in the atom is empty.

Ans. Option (A) is correct.

Explanation: Most of the α-particles pass roughly in a straight line (within 1^0) without deviation. This shows that no force is acting on them. So assertion is true.
Most of the space in the atom is empty. Only 0.14% of α-particles are scattered more than 1°.

Q. 4. Assertion (A): Bohr model is not applicable for multi-electron model.
Reason (R): Bohr model cannot account for sublevel (*s*, *p*, *d*, *f*) orbitals and electron spin.

Ans. Option (A) is correct.

Explanation: Bohr model works well for H and He+ having one electron only. But it does not work for multi-electron atoms, since it cannot account for sublevel (*s*, *p*, *d*, *f*) orbitals and electron spin.
So, assertion and reason both are true and reason explains the assertion.

CASE-BASED MCQs

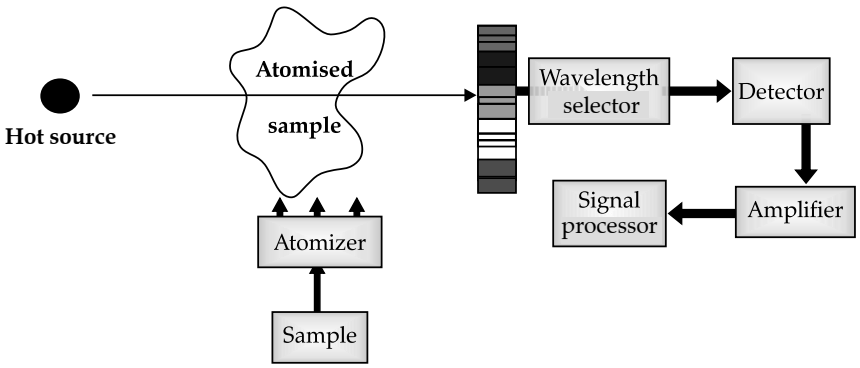
Attempt any 4 sub-parts out of 5. Each sub-part carries 1 mark.

I. Read the following text and answer the following questions on the basis of the same:

Atomic Absorption Spectrometer:

The atomic absorption (AA) spectrometer is used to analyze metals at very low concentrations, typically in the parts per million (ppm) or parts per billion (ppb) ranges. A liquid sample containing dissolved material whose concentration is to be measured is aspirated into a thin, wide AA flame, or is introduced into a small carbon furnace which is heated to a high temperature.

Absorption spectrum



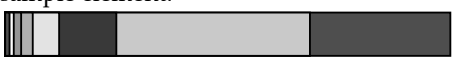
Basic Principle of AAS is the measurement of absorption of radiation by free atoms. The total amount of absorption depends on the number of free atoms present and the degree to which the free atoms absorb the radiation. At the high temperature of the AA flame, the sample is broken down into atoms using an atomizer and it is the concentration of these atoms that is measured.

Sample in the form of solution is used. It is broken up into a fine mist with the help of an atomizer.

When the mist reaches the flame, the intense heat breaks up the sample into its individual atoms.

When a photon coming out from the hot source hits an atom and the energy of the photon is equal to the gap between two electron energy levels of the atom, then the electron in the lower energy level absorb the photon and jumps up to the higher energy level. If the photon energy does not correspond to the difference between two energy levels, then the photon will not be absorbed (it may be scattered away).

Hence in the spectrum, the wavelength corresponding to the absorbed photons is observed as black lines as shown in the following spectrum of Hydrogen. The dark lines correspond to the frequencies of light those have been absorbed by the sample element.



Using this process, a source of photons (generally a white light) of various energies is used to obtain the absorption spectra of different materials and to identify them.

Q. 1. What is the basic principle of Atomic Absorption Spectrophotometer?

(A) Emission of photons when excited electron of an atom comes back to lower energy level.

(B) Absorption of photons when electrons at lower energy level jumps to a higher energy level.

(C) Emission of electrons from an atom at a very high temperature.

(D) Emission of electron when energetic photons bombard an atom.

Ans. Option (B) is correct.

> ***Explanation:*** Basic principle of AAS is the measurement of absorption of radiation by free atoms. When a photon hits an atom and the energy of the photon is equal to the gap between two electron energy levels of the atom, the electron in the lower energy level absorb the photon and jumps up to the higher energy level.

Q. 2. What happens when a photon hits an atom and the energy of the photon is not equal to the gap between two electron energy levels of the atom?

(A) The photon is absorbed and the electron moves to an intermediate energy level.

(B) The photon is absorbed and the electron gets scattered

(C) The photon is not absorbed. It gets scattered.

(D) None of the above

Ans. Option (C) is correct.

> ***Explanation:*** When a photon hits an atom and the energy of the photon is equal to the gap between two electron energy levels of the atom, the electron in the lower energy level absorb the photon and jumps up to the higher energy level. If the photon energy does not correspond to the difference between two energy levels, then the photon will not be absorbed (it may be scattered away).

Q. 3. How the corresponding wavelength of the absorbed photon is represented in the absorption spectrum?

(A) By a black line

(B) By a white line

(C) By a black line in the lower wavelength range and by a white line in the higher wavelength range

(D) By a white line in the lower wavelength range and by a black line in the higher wavelength range

Ans. Option (A) is correct.

> ***Explanation:*** In the spectrum, the wavelength corresponding to the absorbed photons is observed as black lines.

Q. 4. What should be the concentration of metal for analysis using Atomic Absorption Spectrometer?

(A) Very High concentration

(B) Very Low concentration

(C) Medium concentration

(D) Any concentration

Ans. Option (B) is correct.

Explanation: The atomic absorption (AA) spectrometer is used to analyze metals at very low concentrations, typically in the parts per million (ppm) or parts per billion (ppb) ranges.

Q. 5. How the sample for analysis is driven to atomic state in AAS?
(A) At a very high temperature, the sample is driven to its gaseous state
(B) Using an atomizer and then intense heating.
(C) By rotating the solution of the sample at a very high speed.
(D) None of the above

Ans. Option (B) is correct.

Explanation: Sample in the form of solution is used. It is broken up into a fine mist with the help of an atomizer. When the mist reaches the flame, the intense heat breaks up the sample into its individual atoms.

II. Read the following text and answer the following questions on the basis of the same:

Spectrum Analysis and Astronomy

Each element in the periodic table can appear in gaseous form and produce its own spectrum unique to that element. Hydrogen will not look like Helium, which will not look like carbon which will not look like iron... and soon.

Astrophysists can identify what kinds of materials are present in stars from the analysis of star's spectra. This type of study is called astronomical spectroscopy.

The science of spectroscopy is quite sophisticated. From spectrum lines analysis astrophysists can determine not only the element, but the temperature and density of that element in the star. The spectral line also can tell us about any magnetic field of the star.

The width of the line can tell us how fast the material is moving. We can learn about winds in stars from this. The shifting of spectral lines shift back and forth indicates that the star may be orbiting another star.

The following table shows a rough guide for the relationship between the temperature of a star and the electromagnetic spectrum.

Temperature (Kelvin)	Predominant radiation	Astronomical Examples
600 K	Infrared	Planets, warm dust
6,000 K	Optical	The photosphere of Sun and other stars
60,000 K	UV	The photosphere of very hot stars
600,000 K	Soft X-rays	The corona of the Sun
6,000,000 K	X-rays	The coronae of active stars

If the spectrum of a star is red or blue shifted, then it can be used to infer its velocity along the line of sight. Edwin Hubble observed that more distant galaxies tended to have more red shifted spectra. This establishes the theory of expansion of the universe.

Q. 1. What is astronomical spectroscopy?
(A) Study of spectrum of star light and to identify its distance from Earth.
(B) Study spectrum of star light and to identify what kinds of elements are present in stars.
(C) Both (A) and (B)
(D) None of the above

Ans. Option (B) is correct.

Explanation: Astrophysists can identify what kinds of materials are present in stars from the analysis of star's spectra. This type of study is called astronomical spectroscopy.

Q. 2. From the spectrum analysis the following information of a star can be obtained.
(A) Elements present, temperature
(B) magnetic field, density, mass
(C) distance of the star
(D) Both (A) and (B)

Ans. Option (D) is correct.

Explanation: From spectrum lines analysis, astrophysists can determine not only the element, but the temperature and density of that element in the star. The spectral line also can tell us about any magnetic field of the star.

Q. 3. The lines in a star's spectrum is found to shift back and forth. What conclusion may be drawn from this observation?
(A) The star may be orbiting another star
(B) There may be a storm in the star
(C) The star may be rotating at a very high speed
(D) None of the above

Ans. Option (A) is correct.

Explanation: The shifting of spectral lines shift back and forth indicates that the star may be orbiting another star.

Q. 4. What may be the approximate temperature if soft X-rays are found predominantly in the spectrum?
(A) 60000 C **(B)** 600000 C
(C) 60000 K **(D)** 600000 K

Ans. Option (D) is correct.

Explanation: From the table, we find that predominant presence of soft X-rays in the spectrum indicated that the temperature is 600000 K.

Q. 5. Which nature of spectrum establishes the theory of the expanding universe?
(A) Red-shift of spectrum
(B) Blue-shift of spectrum
(C) Back and forth movement of spectral lines
(d) None of the above

Ans. Option (A) is correct.

Explanation: If the spectrum of a star is red or blue shifted, then it can be used to infer its velocity along the line of sight. Edwin Hubble observed that more distant galaxies tended to have more red-shifted spectra. This establishes the theory of expansion of the universe.

❐❐

CHAPTER

13

Term-II

NUCLEI

Syllabus

- Composition and size of nucleus Nuclear force Mass-energy relation, mass defect, nuclear fission, nuclear fusion.

STAND ALONE MCQs (1 Mark each)

Q. 1. The gravitational force between a H-atom and another particle of mass m will be given by Newton's law :

$F = G\frac{M.m}{r^2}$, where r is in km and

(A) $M = m_{proton} + m_{electron}$

(B) $M = m_{proton} + m_{electron} - \frac{B}{c^2}$ (B = 13.6 eV).

(C) M is not related to the mass of the hydrogen atom.

(D) $M = m_{proton} + m_{electron} - \frac{|V|}{c^2}$ ($|V|$= magnitude of the potential energy of electron in the H-atom).

Ans. Option (B) is correct.

Explanation: During formation of H-atom, some mass of nucleons convert into energy by the equation

$$E = mc^2$$

This energy is used to bind the nucleons along with nucleus. So mass of atom becomes slightly less than sum of actual masses of nucleons and electrons.

Actual mass of H-atom

$$= M_p + M_e - \frac{B.E.}{c^2} \quad \left(\frac{B}{c^2} = \text{Binding energy}\right)$$

So, the binding energy of H atoms is 13.6 eV per atom.

Q. 2. Heavy stable nucleus have more neutrons than protons. This is because of the fact that

(A) neutrons are heavier than protons.

(B) electrostatic force between protons are repulsive.

(C) neutrons decay into protons through beta decay.

(D) nuclear forces between neutrons are weaker than that between protons.

Ans. Option (B) is correct.

Explanation: Electrostatic force between proton-proton is repulsive which causes the instability of nucleus. So neutrons are more than the number of protons.

Q. 3. Tritium is an isotope of hydrogen whose nucleus Triton contains 2 neutrons and 1 proton. Free neutrons decay into $p + \bar{e} + \nu$. If one of the neutrons in Tritium decays, it would transform into ${}_2He^3$ nucleus. This does not happen. This is because

(A) tritium energy is less than that of a He^3 nucleus.

(B) the electron created in the beta decay process cannot remain in the nucleus.

(C) both the neutrons in triton have to decay simultaneously resulting in a nucleus with 3 protons, which is not a He^3 nucleus.

(D) because free neutrons decay due to external perturbations which is absent in a triton nucleus.

Ans. Option (A) is correct.

Explanation: Tritium (^3_1H) has 1 proton and 2 neutrons.
If a neutron decays as,
$n \rightarrow p + \bar{e} + \nu$
then nucleus will have 2 protons and 1 neutron, *i.e.* triton atom converts in $_2He^3$ (2 proton and 1 neutron). Binding energy of $_1H^3$ is much smaller than $_2He^3$, so transformation is not possible energetically.

Q. 4. Nuclear force is a _____ and _____ force.
(A) Strong, long-range **(B)** Strong, short range
(C) Weak, long-range **(D)** Weak, short-range

Ans. Option (B) is correct.

Explanation: Nuclear force is the strongest short-range force which binds the neutrons and protons in a nucleus.

Q. 5. Two nuclei have mass number in the ratio 1 : 2. The ratio of their nuclear densities is
(A) 1 : 2
(B) 2 : 1
(C) 1 : 1
(D) Cannot be defined from mass number ratio

Ans. Option (C) is correct.

Explanation: Nuclear density is same for all nuclei.

Q. 6. The mass of a nucleus in its ground state is
(A) less than the total mass of neutrons and protons.
(B) greater than the total mass of neutrons and protons.
(C) equal to the total mass of neutrons and protons.
(D) equal to the total mass of neutron, protons and electrons.

Ans. Option (A) is correct.

Explanation: Protons and neutrons have to come very close to form a nucleus. In order to achieve this closeness, a lot of energy is required. This energy is provided by the nucleons at the expense of certain portion of their masses. For this reason, the mass of a nucleus in its ground state is always less than the total mass of the constituent neutrons and protons.

Q. 7. _____ has the mass closest to the mass of positron.
(A) Proton **(B)** Neutron
(C) Electron **(D)** Neutrino

Ans. Option (C) is correct.

Explanation: Positron is anti-particle of electron.

Q. 8. X amount of energy is required to remove an electron from its orbit and Y amount of energy is required to remove a nucleon from the nucleus.
(A) X = Y **(B)** X > Y
(C) Y > X **(D)** X ≥ Y

Ans. Option (C) is correct.

Explanation: Nuclear force is greater than Coulomb force.

Q. 9. Suppose we consider a large number of containers each containing initially 10,000 atoms of a radio-active material with a half-life of 1 year. After 1 year,
(A) all the containers will have 5,000 atoms of the material.
(B) all the containers will contain the same number of atoms of the material but that number will only be approximately 5,000.
(C) the containers will in general have different numbers of the atoms of the material but their average will be close to 5,000.
(D) none of the containers can have more than 5000 atoms.

Ans. Option (C) is correct.

Explanation: Half-life time for a radio-active substance is defined as the time in which a radio-active atomic substance remains half of its original value of radio-active atom.
Given that,
Half-life = 1 year.
So, after 1 year means one half-life, that is, average atoms of radioactive substance remain after 1 year in each container is equal to half of 10,000 = 5,000 atoms (average).

Q. 10. Consider the following reaction:
$^A_ZX \rightarrow {}^A_{Z+1}Y \rightarrow {}^{A-4}_{Z-1}Z \rightarrow {}^{A-4}_{Z-1}Z$
Radioactive radiation emitted in the following sequence:
(A) β, α, γ **(B)** α, β, γ
(C) γ, β, α **(D)** β, γ, α

Ans. Option (A) is correct.

Explanation: In β-emission, A remains same and Z increases by 1.
In α-emission, A decreases by 4 and Z decreases by 2.
In γ-emission, there is no change in A and Z.

Q. 11. Which of the following material will be the best moderator for a nuclear power plant?
(A) Lighter element
(B) Heavier element
(C) Both of the above
(D) None of the above

Ans. Option (A) is correct.

Explanation: Neutron will be slowed down more if the size of moderator atom is closer to a neutron. For this reason , lighter element will be more efficient moderator.

ASSERTION AND REASON BASED MCQs (1 Mark each)

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

Q. 1. Assertion (A): Two atoms of different elements having same mass number but different atomic numbers are called isobars.

Reason (R): Atomic number is the number of protons present and atomic number is the total number of protons and neutrons present in a nucleus.

Ans. Option (B) is correct.

Explanation: Two atoms of different elements having same mass number but different atomic numbers are called isobars. The assertion is true.

Atomic number is the number of protons present and atomic number is the total number of protons and neutrons present in a nucleus. The reason is also true. But the reason does not explain the assertion.

Q. 2. Assertion (A): Nuclear force is same between neutron-neutron, proton-proton and neutron-proton.

Reason (R): Nuclear force is charge independent.

Ans. Option (A) is correct.

Explanation: Nuclear force acts between nucleons. It is a powerful attractive force and acts in a very short distance.

Neutrons are electrically neutral. So, neutron-neutron is neither attractive nor repulsive force acting. So, Nuclear force binds them together.

Protons are having $+e$ charge each. They experience a repulsive force. But for the short distance, the attractive nuclear force is strong enough to overcome this force.

So, assertion and reason both are true and the reason explains the assertion.

Q. 3. Assertion (A): Electrons do not experience strong nuclear force.

Reason (R): Strong nuclear force is charge independent.

Ans. Option (B) is correct.

Explanation: Nuclear force is a powerful attractive force acts as long as the distance between particles is within 10^{-15} m. This force is charge independent. But as distance increases, the effect of nuclear force rapidly falls.

Electrons are distributed far away. The distance is beyond the range of the nuclear force. Hence nuclear force has no effect on electrons.

So, the assertion and reason both are true. But the reason does not explain the assertion.

Q. 4. Assertion (A): The binding energy per nucleon, for nuclei with mass number (A) > 56 decreases with A.

Reason (R): Nuclear force is weak in heavier nuclei.

Ans. Option (C) is correct.

Explanation: From the binding energy per nucleon vs. mass number, we find that binding energy per nucleon is maximum at A=56. After that, binding energy per nucleon decreases as A increases. So, assertion is true.

Nuclear force remains same for all nuclei. Hence the reason is false.

Q. 5. Assertion (A): Density of all the nuclei is same.

Reason (R): Radius of nucleus is directly proportional to the cube root of mass number.

Ans. Option (A) is correct.

Explanation: Radius of nucleus= $R = R_0A^{1/3}$.

So, Volume of nucleus, $V = \frac{4}{3}\pi R_0^3 A$

Considering mass of proton = mass of neutron $= m$

The mass of the nucleus = $M = mA$

So, density = $M/V = \frac{mA}{\frac{4}{3}\pi R_0^3 A} = \frac{m}{\frac{4}{3}\pi R_0^3}$

So, the mean density is independent of mass number.

So, assertion and reason both are true and the reason properly explains the assertion.

CASE-BASED MCQs

Attempt any 4 sub-parts out of 5. Each sub-part carries 1 mark.

I. Read the following text and answer the following questions on the basis of the same:

India's atomic energy programme :

The atomic energy programme in India was launched around the time of independence under the leadership of Homi J. Bhabha (1909-1966). An early historic achievement was the design and construction of the first nuclear reactor in India (named Apsara) which went critical on August 4, 1956. India indigenously designed and constructed plutonium plant at Trombay, which ushered in the technology of fuel reprocessing (separating useful fissile and fertile nuclear materials from the spent fuel of a reactor). Research reactors that have been subsequently commissioned include ZERLINA, PURNIMA (I, II and III), DHRUVA and KAMINI. KAMINI is the country's first large research reactor that uses U-233 as fuel. The main objectives of the Indian Atomic Energy programme are to provide safe and reliable electric power for the country's social and economic progress and to be self reliant in all aspects of nuclear technology. Exploration of atomic minerals in India undertaken since the early fifties has indicated that India has limited reserves of uranium, but fairly abundant reserves of thorium. Accordingly, our country has adopted a three stage strategy of nuclear power generation. The first stage involves the use of natural uranium as a fuel, with heavy water as moderator. The Plutonium-239 obtained from reprocessing of the discharged fuel from the reactors then serves as a fuel for the second stage — the fast breeder reactors. They are so called because they use fast neutrons for sustaining the chain reaction (hence no moderator is needed) and, besides generating power, also breed more fissile species (plutonium) than they consume. The third stage, most significant in the long term, involves using fast breeder reactors to produce fissile Uranium-233 from Thorium-232 and to build power reactors based on them.

Q. 1. India's atomic energy programme was launched by :

(A) Shanti Swarup Bhatnagar

(B) Homi J. Bhabha

(C) Meghnad Saha

(D) Daulat Singh Kothari

Ans. Option (B) is correct.

> ***Explanation:*** The atomic energy programme in India was launched around the time of independence under the leadership of Homi J. Bhabha (1909-1966).

Q. 2. First nuclear reactor of India :

(A) APSARA **(B)** ZERLINA

(C) DHRUBA **(D)** KAMINI

Ans. Option (A) is correct.

> ***Explanation:*** An early historic achievement was the design and construction of the first nuclear reactor in India named APSARA.

Q. 3. Which one of the following is not a nuclear reactor?

(A) PURNIMA **(B)** DHRUVA

(C) KAMINI **(D)** ARYABHATTA

Ans. Option (D) is correct.

> ***Explanation:*** ARYABHATTA is an Indian artificial satellite.

Q. 4. The main objectives of the Indian Atomic Energy programme :

(A) Development of Nuclear weapons for success in warfare

(B) Generation of safe and reliable electric power

(C) Efficient medical treatment

(D) To breed more fissile species

Ans. Option (B) is correct.

> ***Explanation:*** The main objectives of the Indian Atomic Energy programme are to provide safe and reliable electric power for the country's social and economic progress and to be self -reliant in all aspects of nuclear technology.

Q. 5. India has limited reserves of ....., but fairly abundant reserves of ..... :

(A) Plutonium, Thorium

(B) Thorium, Uranium

(C) Plutonium, Uranium

(D) Uranium, Thorium

Ans. Option (D) is correct.

> ***Explanation:*** Exploration of atomic minerals in India undertaken since the early fifties has indicated that India has limited reserves of uranium, but fairly abundant reserves of thorium.

II. Read the following text and answer the following questions on the basis of the same:

Grand Unification Theory :

There are four fundamental forces in the universe :

- Gravitational force
- Electromagnetic force
- The weak nuclear force
- The strong nuclear force

The weak and strong forces are effective only over a very short range and dominate only at the level of subatomic particles.

Gravitational force and Electromagnetic force have infinite range.

The Four Fundamental Forces and their strengths

(i) Gravitational Force – Weakest force; but has infinite range.

(ii) Weak Nuclear Force – Next weakest; but short range.

(iii) Electromagnetic Force – Stronger, with infinite range.

(iv) Strong Nuclear Force – Strongest; but short range.

Unification :

- The weak nuclear force and electromagnetic force have been unified under the Standard Electroweak Theory, (Glashow, Weinberg and Salaam were awarded the Nobel Prize for this in 1979).
- Grand unification theories attempt to treat both strong nuclear force and electroweak force under the same mathematical structure.
- Theories that add gravitational force to the mix and try to unify all four fundamental forces into a single force are called Superunified Theories. It has not yet been successful.

Q. 1. What are the 4 fundamental forces ?

(A) Gravitational force, electromagnetic force, nuclear force, Tension force

(B) Gravitational force, electromagnetic force, nuclear force, Frictional force

(C) Gravitational force, electromagnetic force, weak nuclear force, strong nuclear force

(D) Frictional force, electric force, nuclear force, magnetic force

Ans. Option (C) is correct.

> ***Explanation:*** There are four fundamental forces in the universe :
> - Gravitational force
> - Electromagnetic force
> - the weak nuclear force
> - the strong nuclear force

Q. 2. Which fundamental force is always attractive ?

(A) Electric force

(B) Magnetic force

(C) Gravitational force

(D) Strong nuclear force

Ans. Option (C) is correct.

> ***Explanation:*** Gravitational force is always attractive. There is no repulsive gravitational force.

Q. 3. Which two fundamental forces have been unified by Standard Electroweak Theory ?

(A) Weak nuclear force and electromagnetic force

(B) Strong nuclear force and electromagnetic force

(C) Gravitational force and electromagnetic force

(D) Weak nuclear force and strong nuclear force

Ans. Option (A) is correct.

> ***Explanation:*** The weak nuclear force and electromagnetic force have been unified under the Standard Electroweak theory. For this, Glashow, Weinberg and Salaam were awarded the Nobel Prize in 1979.

Q. 4. Which one is the weakest force ?

(A) Weak nuclear force

(B) Electromagnetic force

(C) Strong magnetic force

(D) Gravitational force

Ans. Option (D) is correct.

> ***Explanation:*** Gravitational force is the weakest force.

Q. 5. Which of the following forces have infinite ranges?

(A) Weak nuclear force and strong nuclear force

(B) Gravitational force and Electromagnetic force

(C) Weak nuclear force and Gravitational force

(d) All the forces

Ans. Option (B) is correct.

> ***Explanation:*** Gravitational force and Electromagnetic force are extended upto infinity.

❐❐

PART – IX : ELECTRONIC DEVICES

Term-II

CHAPTER 14

SEMICONDUCTOR ELECTRONICS: MATERIALS, DEVICES AND SIMPLE CIRCUITS

Syllabus

- Energy bands in conductors, semiconductors and insulators (qualitative ideas only) Semiconductor diode - I-V characteristics in forward and reverse bias, diode as a rectifier; Special purpose p-n junction diodes: LED, photodiode, solar cell.

STAND ALONE MCQs (1 Mark each)

Q. 1. In an *n*-type silicon, which of the following statement is true :

(A) Electrons are majority carriers and trivalent atoms are the dopants.

(B) Electrons are minority carriers and pentavalent atoms are the dopants.

(C) Holes are minority carriers and pentavalent atoms are the dopants.

(D) Holes are majority carriers and trivalent atoms are the dopants.

Ans. Option (C) is correct.

> ***Explanation:*** In an *n*-type silicon the holes are the minority carriers. An *n*-type semiconductor is obtained when pentavalent atoms, such as phosphorus, are doped in silicon atoms.

Q. 2. Which of the statements given in Q. 1 is true for *p*-type semiconductors?

Ans. Option (D) is correct.

> ***Explanation:*** In a *p*-type semiconductor, the holes are the majority carriers, while the electrons are the minority carriers. A *p*-type semiconductor is obtained when trivalent atoms, such as aluminium, are doped in silicon atoms.

Q.3. Carbon, silicon and germanium have four valence electrons each. These are characterised by valence and conduction bands separated by energy band gap respectively equal to $(E_g)_C$, $(E_g)_{Si}$ and $(E_g)_{Ge}$ Which of the following statements is true?

(A) $(E_g)_{Si} < (E_g)_{Ge} < (E_g)_C$

(B) $(E_g)_C < (E_g)_{Ge} > (E_g)_{Si}$

(C) $(E_g)_C > (E_g)_{Si} > (E_g)_{Ge}$

(D) $(E_g)_C = (E_g)_{Si} = (E_g)_{Ge}$

Ans. Option (C) is correct.

> ***Explanation:*** Above mentioned three given elements, the energy band gap of carbon is the maximum and that of germanium is the least. The energy band gaps of these elements are related as :
>
> $$(E_g)_C > (E_g)_{Si} > (E_g)_{Ge}$$

Q. 4. The conductivity of a semiconductor increases with increase in temperature because

(A) number density of free current carriers increases.

(B) relaxation time increases.

(C) both number density of carriers and relaxation time increase.

(D) number density of current carriers increases; relaxation time decreases but effect of decrease in relaxation time is much less than the increase in number density.

Ans. Option (D) is correct.

Explanation: In semiconductor, the density of charge carriers (electron, holes) are very small, so its resistance is high. When temperature increases, the charge carriers (density) increases which increases the conductivity. As temperature of semiconductor increases, the speed of free electrons increases which decreases the relaxation time. As the density of charge carrier is small, so there is small effect on decrease of relaxation time.

Q. 5. Hole is

(A) an anti-particle of electron.

(B) a vacancy created when an electron leaves a covalent bond.

(C) absence of free electrons.

(D) an artificially created particle.

Ans. Option (B) is correct.

Explanation: Atoms of semiconductor are binding by covalent bonds between the atoms of same or different type. Due to thermal agitation when an electron leaves its position and become free, it leaves a vacancy of electron and this vacancy in the bond (covalent) is called hole.

Q. 6. Semiconductors behave like insulators at _____

(A) 0°C **(B)** 0 K

(C) 273 K **(D)** None of the above

Ans. Option (B) is correct.

Explanation: At 0 K temperature, all electrons of semiconductor are immovable from their shell as they do not have sufficient energy. So no free electron is available as charge carrier. This make the insulators to behave like insulators.

Q. 7. When the conductivity of a semiconductor is due to rupture of its covalent bond only then the semiconductor is called

(A) Intrinsic **(B)** Extrinsic

(C) Donor **(D)** acceptor

Ans. Option (A) is correct.

Explanation: In intrinsic semiconductor, conductivity increases with rise of temperature due to rupture of covalent bonds and thus charge carriers become available.
In extrinsic semiconductor, conductivity increases due to doping and also due to rupture of covalent bonds with rise of temperature.

Q. 8. Tetra valent semiconductor is to be doped with ____ valent element to achieve _____ type extrinsic semiconductor.

(A) penta, *n* **(B)** tri, *p*

(C) penta, *p* **(D)** both (A) and (B)

Ans. Option (D) is correct.

Explanation: When a semiconductor having 4 valence electrons is doped with an element having 3 valence electrons, then an excess hole is generated and the semiconductor becomes *p*-type extrinsic semiconductor.
When a semiconductor having 4 valence electrons is doped with an element having 5 valence electrons, then an excess electron becomes available and the semiconductor becomes *n*-type extrinsic semiconductor.

Q. 9. In an unbiased *p*-*n* junction, holes diffuse from the *p*-region to *n*-region because

(A) free electrons in the *n*-region attract them.

(B) they move across the junction by the potential difference.

(C) hole concentration in *p*-region is more as compared to *n*-region.

(D) All the above.

Ans. Option (C) is correct.

Explanation: The diffusion of charge carriers across a junction takes place from the regions of higher concentration to lower concentration. In this case, the *p*-region has greater concentration of holes than the *n*-region. Hence, in an unbiased *p*-*n* junction, holes diffuse from the *p*-region to the *n*-region.

Q. 10. When a forward bias is applied to a *p*-*n* junction, it

(A) raises the potential barrier.

(B) reduces the majority carrier current to zero.

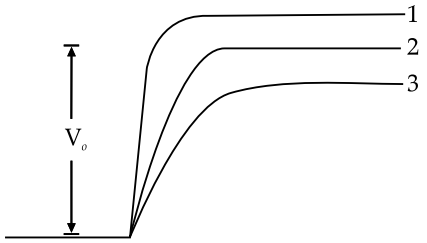
(C) lowers the potential barrier.

(D) None of the above

Ans. Option (C) is correct.

Explanation: When a forward bias is applied to a *p*-*n* junction, it lowers the value of potential barrier. In the case of a forward bias, the potential barrier opposes the applied voltage. Hence, the potential barrier across the junction gets reduced.

Q. 11. In Figure, V_o is the potential barrier across a *p*-*n* junction, when no battery is connected across the junction



(A) 1 and 3 both correspond to forward bias of junction

(B) 3 corresponds to forward bias of junction and 1 corresponds to reverse bias of junction

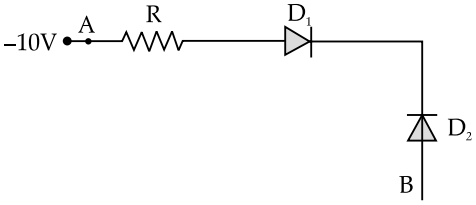
(C) 1 corresponds to forward bias and 3 corresponds to reverse bias of junction.

(D) 3 and 1 both correspond to reverse bias of junction.

Ans. Option (B) is correct.

> ***Explanation:*** When *p-n* junction is in forward bias, it compresses or decreases the depletion layer, due to which potential barrier in forward bias decreases and in reverse bias potential barrier increases.

Q. 12. In Figure, assuming the diodes to be ideal,



(A) D_1 is forward biased and D_2 is reverse biased and hence current flows from A to B

(B) D_2 is forward biased and D_1 is reverse biased and hence no current flows from B to A and vice versa.

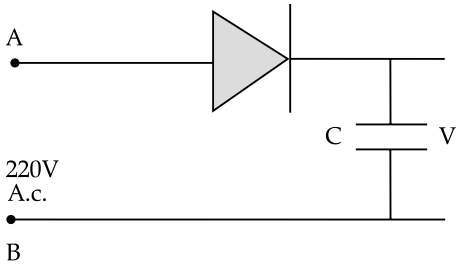
(C) D_1 and D_2 are both forward biased and hence current flows from A to B.

(D) D_1 and D_2 are both reverse biased and hence no current flows from A to B and vice versa.

Ans. Option (B) is correct.

> ***Explanation:*** In circuit, A is at −10 V and B is at 0 V. So B is positive than A. So D_2 is in forward bias and D_1 is in reverse bias, so no current flows from A to B or B to A.

Q. 13. A 220 V A.C. supply is connected between points A and B in Figure. What will be the potential difference V across the capacitor?



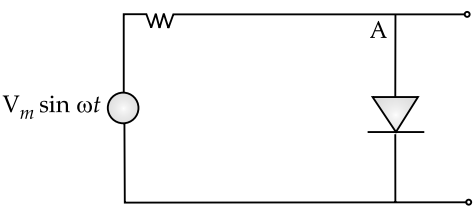
(A) 220 V **(B)** 110 V

(C) 0 V **(D)** $220\sqrt{2}$ V

Ans. Option (D) is correct.

> ***Explanation:*** Potential difference across capacitors will be peak voltage when diode is in forward bias. Diode will be in forward bias when end A is at positive potential of cycle.
>
> So potential at C = peak value of V = $V_{rms} = \sqrt{V}$

Q. 14. The output of the given circuit in Figure



(A) would be zero at all times.

(B) would be like a half wave rectifier with positive cycles in output.

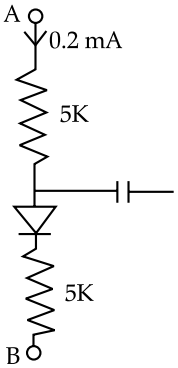
(C) would be like a half wave rectifier with negative cycles in output.

(D) would be like that of a full wave rectifier.

Ans. Option (C) is correct.

> ***Explanation:*** When positive cycle is at A, diode will be in forward bias and resistance due to diode is approximately zero so potential across diode will be about zero.
>
> Similarly, when there is negative half cycle at A, diode will be in reverse bias and resistance will be maximum so potential difference across diode is $V_m \sin \omega t$ with negative at A. So we get only negative output at A, so it behaves like a half-wave rectifier with negative cycle at A in output, verifies the answer (C).

Q. 15. In the circuit shown in Figure, if the diode forward voltage drop is 0.3 V, the voltage difference between A and B is



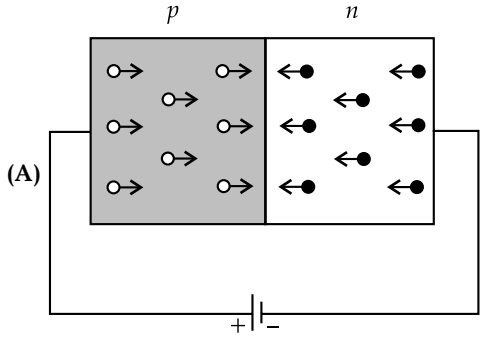
(A) 1.3 V **(B)** 2.3 V

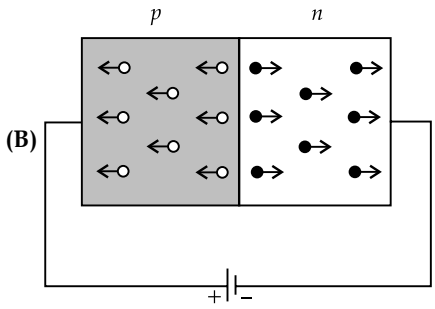
(C) 0 V **(D)** 0.5 V

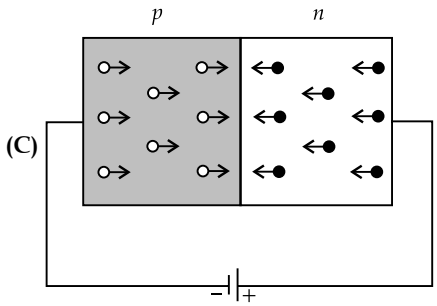
Ans. Option (B) is correct.

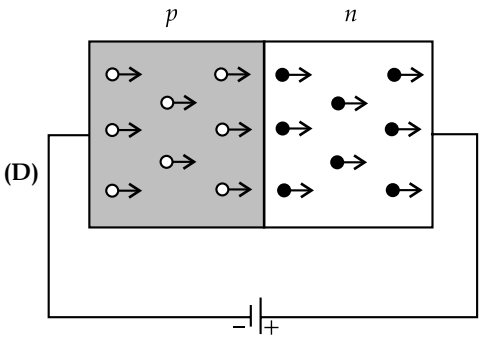
> ***Explanation:*** In the middle right of the circuit the capacitor behaves like an open circuit for *dc* 0.2 mA current, so current will flow from A to B only. Let potential across A and B is V, so by Kirchhoff's loop law,
>
> $V_{AB} = (5{,}000 \times 0.2 \times 10^{-3}) + 0.3 + 5{,}000 \times 0.2 \times 10^{-3}$
>
> $V_{AB} = 1\text{ V} + 0.3\text{ V} + 1\text{ V}$
>
> $V_{AB} = 2.3\text{ V}$

Q. 16. Which one of the following diagrams depicts the proper flow or electrons and holes in a forward biased *p-n* junction diode?









Ans. Option (A) is correct.

> ***Explanation:*** In a forward biased *p*-*n* junction diode, the positive terminal of the battery is connected to the *p*-side and negative terminal of the battery is connected to the *n*-side of the diode.
> Holes flow from *p*-side to *n*-side and electrons flow from *n*-side to *p*-side.

ASSERTION AND REASON BASED MCQs (1 Mark each)

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

Q. 1. Assertion (A): The number of electrons in a *p*-type silicon semiconductor is less than the number of electrons in intrinsic silicon semiconductor at room temperature.
Reason (R): It is due to law of mass action.

Ans. Option (A) is correct.

> ***Explanation:*** In *p*-type semiconductor, electron is the minority charge carrier. So, number of electrons is less than the number of electrons in intrinsic semiconductor. So the assertion is true. According to the law of mass action $= n_i^2 = n_e \times n_h$. In intrinsic semiconductor, $n_e = n_h$. So in *p*-type semiconductor, $n_e < n_h$. So reason is also true.

Q. 2. Assertion (A): The resistivity of a semiconductor decreases with temperature.
Reason (R): The atoms of a semiconductor vibrate with larger amplitude at higher temperature there by increasing it's resistivity.

Ans. Option (D) is correct.

> ***Explanation:*** Resistivity of semiconductors decreases with temperature. So, assertion is true. Electrons from valence band jumps to conduction band with rise of temperature and hence the resistivity decreases. Hence, the reason is also false.

Q. 3. Assertion (A): As the temperature of a semiconductor increases, its resistance decreases.
Reason (R): The energy gap between conduction band and valence band is small.

Ans. Option (A) is correct.

> ***Explanation:*** As temperature rises, the electrons of valence band sufficient energy and jump to conduction band. Thus, the resistivity decreases. So assertion is true.
> In semiconductors the energy gap between conduction band and valence band is small. Due to this, the electrons in conduction band can gain sufficient thermal energy with temperature rise and can easily jump across the small energy gap to reach conduction band. Thus, conductivity increases and resistance decreases.

Q. 4. Assertion (A): Silicon is preferred over Germanium for making semiconductor devices.
Reason (R): The energy gap of Germanium is more than the energy gap of Silicon.

Ans. Option (B) is correct.

> ***Explanation:*** Silicon is preferred over Germanium for making semiconductor devices. The assertion is true.
> The energy gap of Germanium is about 0.7 eV, where as the energy gap of Silicon is 1.1 eV. Hence, the reason is false.

Q. 5. Assertion (A): Semiconductors do not obey Ohm's law.
Reason (R): V-I characteristic of semiconductors is linear.

Ans. Option (C) is correct.

> ***Explanation:*** Semiconductors do not obey Ohm's law. So the assertion is true. V-I characteristic of semiconductor is non-linear. Hence the reason is false.

Q. 6. Assertion (A): Zener diode is used as a voltage regulator.
Reason (R): Zener diode operated in reverse biased condition.

Ans. Option (B) is correct.

Explanation: Zener diode is used as a voltage regulator in reverse biased condition. So, both assertion and reason are true, but the reason does not explain the assertion.

Q. 7. Assertion (A): Ideal diode shows zero resistance in forward bias and infinite resitance in reverse bias.
Reason (R): Depletion region of a *p-n* junction diode extends in reverse bias and contracts in reverse bias.

Ans. Option (A) is correct.

Explanation: In forward bias condition, the depletion region of a *p-n* junction diode contracts and the majority charge carriers can cross the junction very easily. So, the resistance becomes low (ideally 0).
In reverse bias condition, the depletion region of *p-n* junction diode expands and the majority charge carriers cannot cross the junction. So, the resistance increases (ideally ∞).
So, the assertion and reason both are true and reason explains the assertion.

Q. 8. Assertion (A): When diode is used as a rectifier, its specified reverse breakdown voltage should not be exceeded.
Reason (R): When *p-n* junction diode crosses the reverse break down voltage, it get destroyed.

Ans. Option (A) is correct.

Explanation: When a diode is used as a rectifier, it has to face both positive and negative halves of the alternating voltage. Care is taken so that the amplitude of the negative half cycle of the alternating voltage should not be more than the specified reverse breakdown voltage of the diode. So the assertion is true.
Reverse break down voltage of normal *p-n* junction diodes used as a rectifier is high. If reverse voltage exceeds this specified break down voltage, then the diode gets permanently damaged. So, the reason is also true and explains the assertion.

Q. 9. Assertion (A): When a *p-n* junction diode is reverse biased, a feeble reverse current flows known as reverse saturation current.
Reason (R): In reverse bias condition, the minority carries can cross the junction.

Ans. Option (A) is correct.

Explanation: When a *p-n* junction is reverse biased, then the majority charge carriers cannot cross the junction. So, no forward current flows. But in reverse direction, a feeble current flows which is known as reverse saturation current. So, the assertion is true.
In *p*-side there are few electrons as minority charge carrier and in *n*-side, there are few holes as minority charge carriers. In reverse bias condition, the holes at *n*-side feel a pull exerted by the negative polarity of the voltage source connected to the *p*-side. Similarly, the electrons at *p*-side feel a pull exerted by the positive polarity of the voltage source connected to the *n*-side. So, these minority carries now can cross the junction and give rise to a feeble current in the opposite direction. Hence, the reason is also true and it explains the assertion.

CASE-BASED MCQs

Attempt any 4 sub-parts out of 5. Each sub-part carries 1 mark.

I. Read the following text and answer the following questions on the basis of the same:
Band theory of solid:
Consider that the Si or Ge crystal contains N atoms. Electrons of each atom will have discrete energies in different orbits. The electron energy will be same if all the atoms are isolated, i.e., separated from each other by a large distance. However, in a crystal, the atoms are close to each other (2 Å to 3 Å) and therefore the electrons interact with each other and also with the neighbouring atomic cores. The overlap (or interaction) will be more felt by the electrons in the outermost orbit while the inner orbit or core electron energies may remain unaffected. Therefore, for understanding electron energies in Si or Ge crystal, we need to consider the changes in the energies of the electrons in the outermost orbit only. For Si, the outermost orbit is the third orbit (n = 3), while for Ge it is the fourth orbit (n = 4). The number of electrons in the outermost orbit is 4 (2s and 2p electrons). Hence, the total number of outer electrons in the crystal is 4N. The maximum possible number of outer electrons in the orbit is 8 (2s + 6p electrons). So, out of the 4N electrons, 2N electrons are in the 2N s-states (orbital quantum number l = 0) and 2N electrons are in the available 6N *p*-states. Obviously, some *p*-electron states are empty. This is the case of well separated or isolated atoms.

Q. 1. The energy of electrons of atoms of a substance will be same if:
(A) atoms are isolated.
(B) atoms are closely spaced.
(C) atoms are excited.
(D) atoms are charged.

Ans. Option (A) is correct.

Explanation: The electron energy will be same if all the atoms are isolated, *i.e.*, separated from each other by a large distance.

Q. 2. In a crystal, the distance between two atoms is:
(A) 200 Å to 300 Å **(B)** 2 Å to 3 micron
(C) 2 Å to 3 Å **(D)** 2 mm to 3 mm

Ans. Option (C) is correct.

> ***Explanation:*** In a crystal, the atoms are closed to each other (2 Å to 3 Å).

Q. 3. The overlap (or interaction) will be more felt by the electrons when they are:
(A) in the outermost orbit.
(B) in the innermost orbit.
(C) free.
(D) in any orbit.

Ans. Option (A) is correct.

> ***Explanation:*** The overlap (or interaction) will be more felt by the electrons in the outermost orbit, while the inner orbit or core electron energies may remain unaffected.

Q. 4. For Silicon and Germanium the outermost orbits are respectively:
(A) $n = 3$ and $n = 5$ **(B)** $n = 4$ and $n = 3$
(C) $n = 5$ and $n = 4$ **(D)** $n = 3$ and $n = 4$

Ans. Option (D) is correct.

> ***Explanation:*** For Si, the outermost orbit is the third orbit ($n = 3$), while for Ge it is the fourth orbit ($n = 4$).

Q. 5. The maximum possible electrons in an orbit is:
(A) 8 ($2s + 6p$ electrons)
(B) 8 ($6s + 2p$ electrons)
(C) 8 ($4s + 4p$ electrons)
(D) 8 ($1s + 7p$ electrons)

Ans. Option (A) is correct.

> ***Explanation:*** The maximum possible number of outer electrons in the orbit is 8 ($2s + 6p$ electrons).

II. Read the following text and answer the following questions on the basis of the same:

Light Emitting Diode:

It is a heavily doped *p-n* junction which under forward bias emits spontaneous radiation. The diode is encapsulated with a transparent cover so that emitted light can come out. When the diode is forward biased, electrons are sent from $n \rightarrow p$ (where they are minority carriers) and holes are sent from $p \rightarrow n$ (where they are minority carriers). At the junction boundary, the concentration of minority carriers increases as compared to the equilibrium concentration (*i.e.*, when there is no bias).

Thus at the junction boundary on either side of the junction, excess minority carriers are there which recombine with majority carriers near the junction. On recombination, the energy is released in the form of photons. Photons with energy equal to or slightly less than the band gap are emitted. When the forward current of the diode is small, the intensity of light emitted is small. As the forward current increases, intensity of light increases and reaches a maximum. Further increase in the forward current results in decrease of light intensity. LED's are biased such that the light emitting efficiency is maximum.

The V-I characteristics of a LED is similar to that of a Si junction diode. But, the threshold voltages are much higher and slightly different for each colour. The reverse breakdown voltages of LED's are very low, typically around 5 V. So care should be taken that high reverse voltages do not appear across them. LED's that can emit red, yellow, orange, green and blue light are commercially available.

Q. 1. LED is a:
(A) lightly doped *p-n* junction diode.
(B) heavily doped *p-n* junction diode.
(C) moderately doped *p-n* junction diode.
(D) two back to back *p-n* junction diode.

Ans. Option (B) is correct.

> ***Explanation:*** LED is a heavily doped *p-n* junction diode.

Q. 2. LED emits light:
(A) when reversed biased.
(B) when forward biased.
(C) when forward or reverse biased.
(D) when heated.

Ans. Option (B) is correct.

> ***Explanation:*** LED under forward bias emits spontaneous radiation.

Q. 3. During recombination at the junction, emitted photons have:
(A) energy greater than the band gap.
(B) energy equal to or slightly less than the band gap.
(C) energy which has no relation with the band gap.
(D) very low energy compared to band gap.

Ans. Option (B) is correct.

> ***Explanation:*** On recombination, the energy is released in the form of photons. Photons with energy equal to or slightly less than the band gap are emitted.

Q. 4. Threshold voltage of LED is:
(A) lower compared to other *p-n* junction diodes and slightly different for each colour.
(B) higher compared to other *p-n* junction diodes and slightly different for each colour.
(C) higher compared to other *p-n* junction diodes and same for all colours.
(D) lower compared to other *p-n* junction diodes and same for all colours.

Ans. Option (B) is correct.

> ***Explanation:*** The V-I characteristics of a LED is similar to that of a Si junction diode. But the threshold voltages are much higher and slightly different for each colour.

Q. 5. The reverse breakdown voltages of LED's are:
(A) very low and typically around 0.5 V.
(B) very low and typically around 5 V.
(C) very high and typically around 50 V.
(D) very low and typically around 0.05 V.

Ans. Option (B) is correct.

> ***Explanation:*** The reverse breakdown voltages of LED's are very low, typically around 5 V.

❐❐

Exclusive School Books Suppliers

	TELANGANA
HYDERABAD	Sri Balaji Book Depot , 9676996199, (040) 27613300
	ANDHRA PRADESH
GUNTUR	Y Renuka Devi, 9490450750
	ASSAM
WEST KAMENG	Dutta Book Stall, 9402477623, 8729948473
	GUJARAT
JAMNAGAR	Vidyarthi Book Centre (S.S.D.), 9879014367
RAJKOT	Royal Stationery, 9824207514
	KARNATAKA
TUMKUR	Palasandra Promoters, 9448214377, (0816) 2273220
	TAMIL NADU
SALEM	Salem Book House, 9443324584, (0427) 2411315
	HARYANA
PANCHKULA	Raghubar Dass Sat Prakash, 8950055303
	MADHYA PRADESH
INDORE	Raghav Pustak Sadan (S.S.D.), 7772988088
	MAHARASHTRA
KOLHAPUR	Ashish Book Depot, 7798420420, Jai Book Co., 9422046679
PUNE	Sai Shubham, 9975687687, (020) 69498635, Goel Mini Market, 9890825884, 9028943031, Praveen Sales, 9890683475
	Vardhaman Educational, 9834678521
JALNA	Anil Paper Mart, 9422722522, (02482) 230733
WARDHA	Unique Traders, (07152) 243617, 8600044411, 9960644752
	WEST BENGAL
KOLKATA	Eureka book Emporium, (033) 25934001, 9433089132
	Schoolwale & Company, 9731715655
	MANIPUR
IMPHAL	Jain Book Shop, 9856031157
	UTTAR PRADESH
MIRZAPUR	Pustak Bhawan, 9936500469
AGRA	Maheshwari Pustak Bhandar, 9760602503
KARWI	Ramji & Sons, 9026303241

OUR DISTRIBUTORS

	ANDHRA PRADESH
GUNTUR	Y Renuka Devi, (0863) 2252308, 9490450750
HYDERABAD	Sri Balaji Book Depot, (040) 27613300, 9866355473
VIJAYAWADA	Sri Kanaka Durga Book Stall, 9603491009, 9849144007
	Akshaya Books Corner, 9666155555
VISAKHAPATNAM	Sri Rajeshwari Book Link, (0891) 6661718, 9848036014
	ASSAM
GUWAHATI	Ashok Publication, 7002846982, Book Emporium, 9675972993, 6000763186
	Kayaan Enterprises, (0361) 2630443, BLJ Publications, 7086099332
TINSUKIA	C. R. Book House, 9957886562
	BIHAR
JHANJHARPUR	Krishna Book Agency, 9801019292, 9304977755
PATNA	Bokaro Student Friends, (0612) 2300600, 2618400, Gyan Ganga Ltd., 9304826651
	Nova Publisher & Distributors, (0612) 2666404,
	Sharda Pustak Bhandar, 8877279953, Shri Durga Pustak Mandir, 9334477386
	Vikas Book Depot, (0612) 2304753, 7004301983
PURNIA	Chaurasia Book Centre, 9006717044, 7004456102
	CHATTISGARH
RAIPUR	Agarwal Traders & Pub., (0771) 4044423, 7489991679, 8878568055 (W. app)
	Gupta Pustak Mandir, 9329100851
DURG	Bhagwati Bhawani Book Depot, 7882327620, 9827473100
	DELHI
DELHI	Mittal Books, (011) 23288887, 9899037390
	Bokaro,Student Friends Pvt Ltd., 7004074900
	R. D. Chawla & Sons, 9899445522, Zombozone, 9871274082
NOIDA	Prozo (Global Edu4 Share Pvt. Ltd), 9899037390, 8587837835, 9318395520
	Global Islamic Publication, 9873690828
	GUJARAT
AHMEDABAD	Patel Book, 9898184248, 9824386112, 9825900335
VADODARA	Pooja Book Shop, 7600817198, (0265) 2280464
VAPI	Goutam Book Sellers, 9081790813
NAVSARI	College Store, 8141913750
	JHARKHAND
BOKARO	Bokaro Student Friends, (0654) 2233094, 7360021503
	Sahu Pustak Bhandar, 9431378296, 7979845480
DHANBAD	Bokaro Student Friends, (0326) 3590527
RANCHI	Bokaro Student Friends, 9234628152, Gyan Ganga Ltd., 9117889900
	KARNATAKA
BENGALURU	Sri Sai Ram Book traders, 9738881088
GULBARGA	L.E. Bhavikatti, (08472) 261400, 9880737400
HUBLI	Renuka Book Distributor, (0836) 2244124
BELLARY	Chaitanya Exhibition, Bellary - 9886393971
	KERALA
ERNAKULAM	Asad Book Centre, (0484) 2370431, 9447314548, Academic Book House, (0484) 2376613
KADAVANTHRA	H & C Stores, (0484) 2203683, 2204683, 9446411997
JOMES SRINILAYAM	H & C Store, (0484) 2351233
KOTTAYAM	H & C Store, (0481) 2304351, Book Centre, (0481) 2566992
TRIVANDRUM	Academic Book House, (0471) 2333349, 9447063349,
CALICUT	Aman Book Stall, (0495) 2721282,
	MADHYA PRADESH
MORENA	Shri Ram Book Store, 9424603124
GWALIOR	Agarwal Book Depot, 9425116210
INDORE	Student Book Depot, (0731) 2503333, 2535892, 9425322330
	Arun Prakashan, (0731) 2459448, 9424890785
REWA	Siddharth Enterprises, 9425185072
JABALPUR	Sangam General Store, (0761) 2412592, Akash Book Distributor, 7974264828
	New Radhika Book Palace, 9425411533-66
	GOA
MARGO	Golden Heart Emporium, (0832) 2725208, 9370273479
	HARYANA
ROHTAK	Swami Kitab Ghar, 9255121948
	MANIPUR
IMPHAL	Jain Book Shop, 9856031157
	MAHARASHTRA
AHMEDNAGAR	Hira Stationers, 9423755472
MUMBAI	Shivam Books & Stationery, (022) 28230897, 9892935799
	Student Book Depot, 9821550165
PUNE	Natraj Book Depot., (020) 24485054, 9890054092
	Akshar Books & Stationary, 7385089789
	Kirti Book Agnecies, 9881190907
YAVATMAL	Dilip Book Agency, (0823) 2245450, 9423131275
NANDED	Abhang Pustakalaya, 9823470756
NAGPUR	Laxmi Pustakalay Stationers, (0712) 2727354, Novelty Book Depot, 9657690200
	Vijay Book Depot, 9860122094, (0712) 2520496, 2534217
DHULE	Navjeevan Book Stall, 7020525561
BHUSAWAL	Anil Book Depot, 9403942906
	ODISHA
CUTTACK	A. K. Mishra Agencies, 9437025991, 9437081319
BHUBANESHWAR	M/s Pragnya, 8847888616, 9437943777, Bharati Book House, 9438420527
BARIPADA	Trimurthi Book World, (0679) 2253336 9437034735
	PUNJAB
LUDHIANA	Amit Book Depot., 9815807871, Ravi Book Shop, 9815200925
	Bhatia Book Centre, 9815277131, 7901814043
JALANDHAR	Cheap Book Store, 9872223458, 9878258592, Gaurav Book, 9478821183
	Subhash Book Depot, 9876453625
	City Book Shop, 9417440753
PATIALA	Adarsh Enterprises, 9814347613
BARNALA	Navchetan Book Depot, 9779050692
	RAJASTHAN
KOTA	Raj Traders, (0744) 2429090, 9309232829, 8005529594, Bhandari Stationers, (0744) 231958, Radhe Traders, 8769802001, Perfect Stationers & Gen. Shoppe, 9829863904
BHILWARA	Nakoda Book Depot, (01482) 243653, 9214983594
JAIPUR	J K Enterprises, 9460983939, 9414782130
	Saraswati Book House, (0141) 2610823, 9829811155
	Ravi Entreprises (0141) 2602517, 9828944479
	TAMIL NADU
COIMBATORE	Majestic Book House, (0422) 2384333
	CBSE Book Shop, (0422) 2303533, 8056655337
CHENNAI	Arraba Book Traders, (044) 25387868, 9841459105, M.R. Book Store (044) 25364596, Indian Book House, (044) 24327784, 9094129595,
	Kalaimagal Store, (044) 5544072, 9940619404, Vijaya Stores, 9381037417
	Bookmark It-Books & Stat. Store, 7305151653, M.K. Store, 9840030099
	Tiger Books Pvt. Ltd., 9710447000
PUDUCHERRY	Sri Saraswathi Book Stall, (04132) 222283, 9092626287
OOTY	Bharat & Co., 9095552155
	TRIPURA
AGARTALA	Book Corner, 9856358594, Book Emporium, (0381) 2391509, 9436460399
	UTTAR PRADESH
AGRA	Ajay Book Depot, (0562) 2254621, 9411205449
	Sparsh Book Agency, 9412257817
	Om Pustak Mandir, (0562) 2464014, 9319117771,
	Panchsheel Books, 9412257961, 9412257962,
ALIGARH	Shaligram Agencies (0571) 2421887, 9412317800
ALLAHABAD	Mehrotra, (0532) 2266865, 9415636890
AZAMGARH	Sasta Sahitya Sadan, 9450029674
FARRUKHABAD	Anurag Book, (0569) 2226843, 9839933650
GORAKHPUR	Atul Pustak Bhandar, 9935210622
JAUNPUR	Thakur Pustak, 9795198974, 5453-222298
LUCKNOW	Rama Book Depot, (0522) 4080133, 9956922433 (Retail), Vyapar Sadan, 7607102462
	Azad Book Depot Pvt. Ltd., 7317000250
MORENA	Shri Ram Book Store, 9424603124
MEERUT	Ideal Book Depot, (0121) 4059252, 9837066307
VARANASI	Bokaro Student Friends, (0542) 2401250, 8299344607
	Gupta Books, 9918155500, 8707225564
	UTTARAKHAND
RUDRAPUR	Vinod Pustak Bhandar, 9927866188
VARANASI	Bokaro Student Friends, (0542) 2401250, 8299344607
	Gupta Books, 9918155500, 8707225564
	WEST BENGAL
KOLKATA	Eureka Book, (033) 25934001, 9433089132, Oriental Publishers & Distributor
	(033) 40628367, Katha 'O' Kahani, (033) 22196313, 22419071,
	Saha Book House, (033) 22193671, 9333416484,
	New National Book Store, 8697601392,
SILIGURI	Agarwal Book House, (0353) 2535274, 9832038727

0107