Chapter 1 (Electric charges & Fields)

1. Using Gauss’s law deduce the expression for the electric field due to an uniformly charged spherical conducting shell of radius R at a point (i) outside (ii) inside the shell. Plot a graph showing the variation of electric field as a function of r>R and r<R. (‘r’ being the distance from the centre of the shell) [2013, 2015, 2019]

2. Define electric dipole moment. Is it a scalar or vector? Derive the expression for the electric field of a dipole at a point (i) on the equatorial plane of the dipole. (ii) on the axis of the dipole. [2011, 2013]

3. An electric dipole is held in a uniform electric field. (i) Show that net force acting on it is zero. (ii) Find the torque acting on a dipole and specify its direction (iii) If the dipole is aligned parallel to the field. Find the work done in rotating through the angle of 180°. [2008, 2012]

4. Two identical conducting balls A & B have charges –Q and +3Q respectively. They are brought in contact with each other and then separated by a distance d apart. Find the nature of the coulomb force between them. [2019]

5. Use Gauss’s law to find the electric field due to a uniformly charged infinite plane sheet. What is the direction of field for positive and negative charge densities? [2016, 2017]

6. Two large parallel plane plates, each of area A having surface charge densities +σ and -σ are separated by a distance d in air, find the expressions for (a) Field at point between the two plates and on outer side of the plates. Specify the direction of the field in each case. (b) The potential difference between the plates. (c) The capacitance of the capacitor so formed. [2016, 2019]

7. (a) Derive an expression for the electric field E due to a dipole of length ’2a’ at a point distant r from the centre of the dipole on the axial line. (b) Draw a graph of E versus r for r>>a. (c) If this dipole were kept in a uniform external field E₀, diagrammatically represent the position of the dipole in stable and unstable equilibrium and write the expression for torque acting on the dipole in both cases. [2017]

8. Four point charges Q, q, Q and q are placed at the corners of a square of side ‘a’ as shown in the figure. Find the (a) resultant electric force on a charge Q (b) potential energy of this system. [2018]

9. (a) Define electric flux. Is it a scalar or a vector quantity? (b) A point charge q is at a distance of d/2 directly above the centre of a square of side d, as shown in the figure. Use Gauss’ law to obtain the expression for the electric flux through the square. If the point charge is now moved to a distance ‘d’
from the centre of the square and side of the square is doubled, explain how the electric flux will be affected. [2018]

10. (a) Use Gauss’ law to derive the expression for the electric field due to a straight uniformly charged infinite line of charge density $\lambda\ C/m$. (b) Draw a graph to show the variation of $E$ with perpendicular distance $r$ from the line of charge. [2018]

**Chapter 2 (Electrostatic Potential & Capacitance)**

1. A slab of material of dielectric constant $K$ has the same area as that of the plates of a parallel plate capacitor but has the thickness $d/3$, where $d$ is the separation between the plates. Find out the expression for its capacitance when the slab is inserted between the plates of the capacitor. [2013]

2. Describe schematically the equipotential surface corresponding to a constant electric field in $z$ direction.


4. A parallel plate capacitor is charged by a battery, which is then disconnected. A dielectric slab is then inserted in the space between the plates. Explain what changes if any occur in the values of:
   (i) capacitance (ii) potential difference between the plates (iii) electric field between the plates and (iv) energy stored in the capacitor. [2009, 2012]

5. (a) When a parallel plate capacitor is connected across a dc battery, explain briefly how the capacitor gets charged. (b) A parallel plate capacitor of capacitance $C$ is charged to $V$ volt by a battery. After some time the battery is disconnected and distance between the plate is doubled. Now a slab of dielectric constant $1<k<2$ is introduced to fill the space between the plates. How will the following be affected? The electric field between the plates of capacitor and energy stored in the capacitor. Justify your answer in each case. [2019]

6. Derive an expression for the potential energy of an electric dipole in a uniform electric field. Explain conditions for stable and unstable equilibrium. Is the electrostatic potential necessarily zero at a point where the electric field is zero? Give an example to support your answer. [2019]

**Chapter 3 (Current Electricity)**

1. Under what condition will the current in a wire be the same when connected in series and in parallel of $n$ identical cells each having internal resistance ‘$r$’ and external resistance ‘$R$’? [2019]

2. State the underlying principle of metre bridge. Draw the circuit diagram and explain how the unknown resistance of a conductor can be determined by this method. [2019]

3. Derive an expression for drift velocity of free electrons in a conductor in terms of relaxation time. [2009]

4. (a) Draw a graph showing the variation of current versus voltage in an electrolyte when an external resistance is also connected.
(b) (i) The graph between resistance (R) and temperature (T) for Hg is shown in the figure (a). Explain the behavior of Hg near 4K. (ii) In which region of the graph (b) is resistance negative and why?

5. Draw a neat labelled diagram of a simple potentiometer used to compare the e.m.f. of two cells and explain its principle.

6. For the circuit shown in the figure, how would the balancing length be affected, if (i) $R_1$ is decreased (ii) $R_2$ is increased, the other factors remaining the same in the circuit? Justify your answer in each case. Why is a potentiometer preferred over a voltmeter? Give reason.

7. Define the term mobility and give its SI unit. State the two Kirchhoff's rules used in electric networks. How are these rules justified?

8. Two electric bulbs P and Q have their resistance in the ratio of 1:2. They are connected in series across a battery. Find the ratio of the power dissipation in these bulbs.

9. In a potentiometer arrangement for determining the emf of a cell, the balance point of the cell in open circuit is 350 cm. When a resistance of 9 ohm is used in the external circuit of the cell, the balance point shifts to 300 cm. Determine the internal resistance of the cell.

10. Define the term ‘conductivity’ of a metallic wire. Write its SI unit.

11. Using the concept of free electrons in a conductor, derive the expression for conductivity of a wire in terms of number density and relaxation time. Hence obtain the relation between current density and applied electric field $E$.

Chapter 4 (Moving charges & Magnetism)

1. (a) Deduce an expression for the frequency of revolution of a charged particle in a magnetic field and show that it is independent of velocity or energy of the particle. (b) Draw a schematic sketch of a cyclotron. Explain, giving the essential details of its construction, how it is used to accelerate the charged particles. Write the limitations of cyclotron.

2. Discuss the motion of a charge particle entering in a uniform magnetic field $B$ with velocity ‘$v$’ inclined at an angle $\theta$ with the direction of magnetic field.

3. (a) Draw a labelled diagram of a moving coil galvanometer. Describe briefly its principle and working. (b)(i) Why is it necessary to introduce a cylindrical soft iron core inside the coil of a galvanometer? (ii) Increasing the current sensitivity of a galvanometer may not necessarily increase its voltage sensitivity. Explain, giving reason.
4. Derive the expression for the magnetic field due to a circular coil carrying current at a point along its axis. [2013, 2015]

5. What does a toroid consist of? Find out the expression for the magnetic field inside a toroid for N turns of the coil having the average radius r and carrying a current I. Show that the magnetic field in the open space inside and exterior to the toroid is zero. [2013]

6. Using Ampere's circuital law find an expression for the magnetic field at a point on the axis of a long solenoid with closely wound turns. [2004C, 2013]


8. A proton, a deuteron and an alpha particle, are accelerated through the same potential difference and then subjected to a uniform magnetic field B, perpendicular to the direction of their motions. Compare (i) their kinetic energies, and (ii) if the radius of the circular path described by proton is 5 cm, determine the radii of the paths described by deuteron and alpha particle. [2019]

9. A proton and an electron travelling along parallel paths enter a region of uniform magnetic field, acting perpendicular to their paths. Which of them will move in a circular path with higher frequency? [2018]

10. (a) Briefly explain how a galvanometer is converted into (i) an ammeter (ii) a voltmeter. 
       (b) A galvanometer coil has resistance of 15Ω and it shows full scale deflection for a current of 4mA. Convert it into an ammeter of range 0 to 6 A. 
       (c) A voltmeter of a certain range is constructed by connecting a resistance of 980 Ω in series with a galvanometer. When the resistance of 470 Ω is connected in series, the range gets halved. Find the resistance of the galvanometer. [2019]

Chapter 5 (Magnetism & Matter).
1. Distinguish the magnetic properties of diamagnetic, paramagnetic and ferromagnetic substances in terms of (i) susceptibility (ii) magnetic permeability (iii) coercivity. Give an example for each. Draw the field lines due to an external magnetic field near (i) diamagnetic (ii) paramagnetic substance. [2007]

2. Where on the surface of earth is the angle of dip 90°? [2011]

3. Define intensity of magnetisation of a magnetic material. How does it vary with temperature for a paramagnetic material? [2017]

4. Write two properties of a material suitable for making (a) a permanent magnet, and (b) an electromagnet. [2017]

5. A magnetised needle in a uniform magnetic field experiences a torque but no net force. An iron nail near a bar magnet, however, experience a force of attraction in addition to a torque. Why? [2016]

6. In what way is the behavior of a diamagnetic material different from that of a paramagnetic, when kept in an external magnetic field? [2016]

7. Verify the Gauss’s law for magnetic field of a point dipole of dipole moment m at the origin for the surface which is a sphere of radius R. [EXEMPLAR]

8. The susceptibility of a magnetic material is 0.9853. Identify the type of magnetic material. Draw the modification of the field pattern on keeping a piece of this material in a uniform magnetic field. [2018]

Chapter 6 (Electromagnetic Induction)

1. How does the mutual inductance of a pair of coils change when (i) distance between the coils is increased and (ii) number of turns in the coils is increased? [2013]

2. (a) Draw a labelled diagram of an ac generator. Obtain the expression for the emf induced in the rotating coil of N turns each of cross-sectional area A, in presence of magnetic field B. Show how an alternating emf is generated by a loop of wire rotating in a magnetic field. (b) A horizontal conducting rod 10m long
extending from east to west is falling with a speed 5 m/s at right angles to the horizontal component of
the earth’s magnetic field, 0.3 x 10^{-4}\ \text{Wb m}^{-2}. \text{Find the instantaneous value of emf induced in the rod.} [2017,2018,2019]

3. A wheel with 8 metallic spokes each 50 cm long is rotated with a speed of 120 rev/min in a plane normal
to the horizontal component of the earth’s magnetic field. The earth’s magnetic field at the plane is 0.4G
and the angle of dip is 60^0. Calculate the emf induced between the axle and the rim of the wheel. How
will the value of emf be affected if the number of spokes were increased? [2013]

4. What are eddy currents? How are they produced? How can they be minimized? Give two applications of

5. Write expression for energy stored in an inductor when a steady current I is passed through it. Is this
energy electric or magnetic? Define the term self inductance and give its SI unit. [2017]

6. Define mutual inductance between a pair of coils. Derive an expression for the mutual inductance of two
long coaxial solenoids of same length wound one over the other. [2017]

Chapter 7 (Alternating Current)

1. A voltage $V = V_0 \sin \omega t$ is applied to a series LCR circuit. Derive the expression for the average power
dissipated over a cycle. Under what condition (i) no power dissipated even though the current flows
through the circuit, (ii) maximum power dissipated in the circuit? [2014]

2. (a) For a given a.c., $i = i_m \sin \omega t$, show that the average power dissipated in a resistor $R$ over a complete
cycle is $\frac{1}{2} i_m^2 R$. (b) A light bulb is rated at 100 W for a 220 V a.c. supply. Calculate the resistance of the
bulb. [2013]

3. (a)(i) Draw a labelled diagram of a step-down transformer. State the principle of its working. (ii) Express
the turn ratio in terms of voltages. (iii) Find the ratio of primary and secondary currents in terms of turn
ratio in an ideal transformer. (iv) How much current is drawn by the primary of a transformer
connected to 220V supply when it delivers power to a 110V-550W refrigerator? (b) Write any two
sources of energy loss in a transformer. Can a transformer be used to step up or step down a d.c.
voltage? Justify your answer. (c) How is the large scale transmission of electric energy over long distances done with the use of

4. (a) State the condition for resonance to occur in series LCR a.c. circuit and derive an expression for
resonant frequency. Mention the factors on which the resonant frequency of a series LCR circuit
depends. Plot a graph showing variation of impedance of series LCR with frequency of an ac source. (b)
Draw a plot showing the variation of the peak current with frequency of the a.c. source used. Define
quality factor $Q$ of the circuit. [2008]

5. (i) When an AC source is connected to an ideal inductor show that the average power supplied by the
source over a complete cycle is zero. (ii) A lamp is connected in series with an inductor and an AC source.
What happens to the brightness of the lamp when the key is plugged in and an iron rod is inserted inside
the inductor? Explain. [2016]

6. What do you understand by ‘sharpness of resonance’ for a series LCR resonant circuit? How is it related
with the quality factor ‘Q’ of the circuit? Using the graphs given in the diagram, explain the factors which
affect it. For which graph is the resistance minimum?

7. A 2\( \mu \)F capacitor, 100\( \Omega \) resistor and 8H inductor are connected in series with an ac source. Find the frequency of the ac source for which the current drawn in circuit is maximum. If the peak value of emf of the source is 200V, calculate the (i) maximum current, and (ii) inductive and capacitive reactance of the circuit at resonance.

Chapter-8 (Electromagnetic Waves)

1. Welders wear special goggles or face masks with glass window to protect their eyes from electromagnetic radiations. Name the radiations and write range of their frequency. [2013]
2. The small ozone layer on top of the stratosphere is crucial for human survival. Why? [2019]
3. Name the part of electromagnetic spectrum whose wavelength lies in the range of 10\(^{-10}\)m. Give its one use. [2008,09,10]
4. A parallel plate capacitor is being charged by a time varying current. Explain briefly how Ampere’s circuital law is generalized to incorporate the effect due to the displacement current. [2011]
5. Find wavelength of electromagnetic wave of frequency 6\( \times 10^{12} \)Hz. Gives its two applications. [2014]
6. How can you show that electromagnetic waves carry both energy and momentum? Illustrate by giving suitable examples. [2017,2019]
7. Name the electromagnetic radiations used for (a) water purification, and (b) eye surgery. [2018]
8. (a) Why are infra-red waves often called heat waves? Explain (b) what do you understand by the statement, “Electromagnetic waves transport momentum”? [2018]

Chapter-9 (Ray Optics)

1. Derive the mathematical relation between refractive indices \( n_1 \) and \( n_2 \) of two radii and radius of curvature \( R \) for refraction at a convex spherical surface. Consider the object to be a point since lying on the principal axis in rarer medium of refractive index \( n_1 \) and a real image formed in the denser medium of refractive index \( n_2 \). Hence derive the lens maker’s formula. [2016]
2. How does the angle of minimum deviation of a glass prism vary, if the incident violet light is replaced by red light? Give reason. [2017]
3. Explain the phenomenon of total internal reflection. What are the conditions for phenomenon? Explain the meaning of critical angle. [2000]
4. A convex lens of focal length 25 cm is placed coaxially in contact with a concave lens of focal length 20 cm. Determine the power of combination. Will the system be converging or diverging in nature? [2013]
5. Plot a graph for angle of deviation as a function of angle of incidence for a triangular prism. Derive the relation for refractive index of the prism in terms of the angle of minimum deviation and angle of prism. [2005,2006,2019]
6. Draw a ray diagram to show the image formation of distant object by a refracting telescope. Derive an expression for its magnifying power when final image is (i) at infinity (ii) at least distance of distant vision. State two important considerations required to achieve large resolution and their consequent limitations. [2000,2004,2006,2019]

7. Describe reflecting type telescope. What are its advantages over a refracting telescope? [2009,2018]

8. Draw a ray diagram to show the image formation by a combination of two thin convex lenses in contact. Obtain the expression for the power of this combination in terms of the focal lengths of the lenses. [2017,2019]

9. A ray of light passing from air through an equilateral glass prism undergoes minimum deviation when the angle of incidence is ¾ th of the angle of prism. Calculate the speed of light in the prism. [2017]

10. (a) Draw a ray diagram to show image formation when the concave mirror produces a real, inverted and magnified image of the object. (b) Obtain the mirror formula and write the expression for the linear magnification. [2018]

11. An object is kept in front of a concave mirror of focal length 15 cm. The image formed is real and three times the size of the object. Calculate the distance of the object from the mirror. [2019]

12. A beam of light converges at a point P. Now a convex lens is placed in the path of the convergent beam at 15 cm from P. At what point does a beam converge if the convex lens has a focal length 10 cm? [2019]

Chapter-10 (Wave Optics)

1. Define Wavefront. Use Huygens' principle to verify the laws of reflection. [2017,2018]

2. What type of wavefront will emerge from (i) a point source (ii) distant light source. [2009]

3. What is meant by interference of light? Describe briefly young's double slit experiment to demonstrate interference of light. [2000,2005]

4. How would resolving power of microscope change on (i) decreasing of wavelength of light (ii) decreasing diameter of objective lens. (iii) frequency of incident radiation (iv) focal length of objective lens. [2006,2011,2019]

5. The figure shows a modified Young's double slit experimental set-up. Here SS₂-SS₁ = λ/4. (a) write the condition for constructive interference. (b) obtain an expression for the fringe width.

6. Explain using a suitable diagram, how unpolarized light gets linearly polarized by scattering. [2019]

7. Describe briefly the variation of the intensity of transmitted light when a polaroid sheet kept between two crossed polaroids is rotated. Draw the graph depicting the variation of intensity with the angle of rotation. How many maxima and minima would be observed when θ varies from 0 to π? [2019]

8. (a) In a single slit diffraction experiment, the width of the slit is made double the original width. How does this affect the size and intensity of the central diffraction band? Explain. [2018]

9. When a tiny circular obstacle is placed in the path of light from a distance source, a bright spot is seen at the centre of the obstacle. Explain why. [2018]

10. Show using a proper diagram how unpolarised light can be linearly polarized by reflection from a transparent glass surface. [2018]
Chapter-11 (Dual nature of matter and radiation)

1. An electron and a proton are accelerated through the same potential. Which one of the two has (i) greater value of de-broglie wavelength associated with it, and (ii) lesser momentum? Justify your answer in each case. How momentum of a particle related with its de-broglie wavelength? Show the variation on graph. [2019]

2. Write three silent features observed in photoelectric effect which can be explained using Einstein’s photoelectric equation. [2012]

3. Using photon picture of light, show how Einstein’s photoelectric equation can be established. Write two features of photoelectric effect which cannot be explained by wave theory. [2017]

4. An electron, an α-particle and a proton have same kinetic energy. Which of these particles has the largest De broglie wavelength? [EXEMPLAR, 2007, 2013]

5. State briefly, with what purpose was Davisson and Germer experiment performed and what inference was drawn from this. Obtain an expression for the ratio of the accelerating potentials required to accelerate a proton and an α-particle to have the same de-broglie wavelength associated with them. [2019]

6. Define the terms threshold frequency and stopping potential in relation to the phenomenon of photoelectric effect. How is the photoelectric current affected on increasing the (i) frequency (ii) intensity of incident radiations and why? [2006]

7. The figure shows the variation of stopping potential $V_0$ with the frequency of incident radiation $'\nu'$ for two photo sensitive metals P and Q. which metal has smaller threshold wavelength? Justify your answer. [2019]

8. Draw graph showing variation of photoelectric current with intensity of incident radiation. [2019]

Chapter-12 (Atom)

1. Write an expression for Bohr’s radius in a hydrogen atom. [2010, 2011]

2. Define ionization energy. What is the value for a hydrogen atom? [2010]

3. Using Bohr’s postulate of the atomic model, derive an expression for radius and orbital period of n$^{th}$ orbit of hydrogen atom. Write Rydberg’s formula for wavelengths of the spectral lines of hydrogen atom spectrum. Mention to which series in the emission spectrum of hydrogen, H$\alpha$ line belongs. [2013, 2014, 2019]

4. What is the ratio of radii of orbit corresponding to first excited state and ground state of a H atom? [2010]

5. The total energy of an electron in the ground state of Bohr model of hydrogen atom is 13.6 eV. Obtain the value of potential energy $U$ and kinetic energy $K$ in eV. [2010]

6. The ground state energy of hydrogen atom is -13.6 eV. If an electron makes a transition from an energy level -0.85 eV to -3.4 eV, calculate the wavelength of spectral line emitted. To which series of hydrogen spectrum does this wavelength belong? [2012]

7. A 12.5 eV electron beam is used to excite a gaseous hydrogen atom at room temperature. Determine the wavelengths and the corresponding series of the lines emitted. [2017]
8. A 12.9 eV beam of electrons is used to bombard gaseous hydrogen at room temperature. Upto which energy level the hydrogen atoms would be excited? Calculate the wavelength of the first member of Paschen series and first member of Balmer series. [2014]

9. State Bohr’s postulate to define stable orbits in hydrogen atom. How does de Broglie’s hypothesis explain the stability of these orbits? [2018]

Chapter-13 (Nuclei)

1. Define activity of a radioactive substance. Write its SI unit? [2013]
2. Derive an expression for average life of radioactive nuclei. Give its relationship with half life. [2010]
3. If the nucleons bound in a nucleus are separated apart from each other, the sum of their masses is greater than the mass of the nucleus. Where does this mass difference come from? Explain. [2007]
4. State with reason why light nuclei usually undergo nuclear fission. [2000]
5. Does the neutron to proton ratio in a nucleus increases, decreases or remain same. [2011]
6. Why is it found experimentally difficult to detect neutrinos in nucleus β – decay? [2014]
7. State the law of radioactive decay. If N₀ is the number of radioactive nuclei in the sample at some initial time, t₀, find out the relation to determine the number N present at a subsequent time. Draw a plot of ‘N’ as a function of time. [2008, 2019]
8. Two nuclei have mass numbers in the ratio 1:8. What is the ratio of their nuclear radii? [2009]
9. Deduce the expression N=N₀ e⁻λ/t for the law of radioactive decay. [2014]
10. Show that nuclear density is same for all the nuclei. [2013]
11. Explain the processes of nuclear fission and nuclear fusion by using the plot of binding energy per nucleon (BE/A) versus the mass number A. Write two salient features of the curve. [2018, 2019]

Chapter-14 (Semiconductor electronics, materials, devices and simple circuits)

1. Draw the energy band diagram of n-type and p-type semiconductor at temperature T > 0 K. In case of n-type Si-semiconductor, the donor energy level is slightly below the bottom of conduction band whereas in p-type semiconductor, the acceptor energy level is slightly above the top of valence band. Explain, giving examples, what role do these energy level play in conduction and valence bands. [2019]
2. With what considerations in view is a photodiode fabricated? Explain its working with the help of a suitable diagram. With the help of V-I characteristics, state how photodiode is used to detect optical signals. [2019]
3. In a half wave rectification what is the output frequency if input frequency is 50Hz. What is the output frequency of a full wave rectifier for the same input frequency? [2005]
4. Explain the formation of potential barrier and depletion region in a p-n junction. [2010]
5. What is a p-n junction diode? Explain with help of diagram, how p-n junction is used as full wave rectifier. Draw the input and output waveforms. [2007, 2017, 2018]