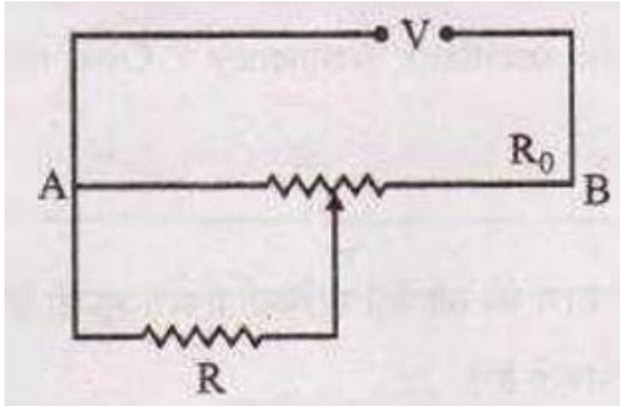
Chapter Wise 100 Very Important conceptual questions and derivations

Electrostatics

1. (i) Derive the expression for electric field at a point on the equatorial line of an electric dipole.
   (ii) Depict the orientation of the dipole in (i) stable, (ii) unstable equilibrium in a uniform electric field. 3
2. A capacitor of capacitance C1 is charged to a potential V1 while another capacitor of capacitance C2 is charged to a potential difference V2. The capacitors are now disconnected from their respective charging batteries and connected in parallel to each other.
   (a) Find the total energy stored in the two capacitors before they are connected.
   (b) Find the total energy stored in the parallel combination of the two capacitors.
   (c) Explain the reason for the difference of energy in parallel combination in comparison to the total energy before they are connected. 5
3. Define an equipotential surface. Draw equipotential surfaces : 3
   (i) in the case of a single point charge and
   (ii) in a constant electric field in z-direction.
   Why the equipotential surfaces about a single charge are not equidistant?
   (iii) Can electric field exist tangential to an equipotential surface? Give reason. 3
4. 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? 3
5. If two similar large 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 points 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.
6. Derive an expression for the work done in rotating a dipole from the angle θo to θi in a uniform electric field E. 1
7. (a) Deduce the expression for the torque acting on a dipole of dipole moment p placed in a uniform electric field $\vec{E}$. Depict the direction of the torque. Express it in the vector form.
   (b) Show that the potential energy of a dipole making angle θ with the direction of the field is given by u(θ)=- $\vec{p}.\vec{E}$. Hence find out the amount of work done in rotating it from the position of unstable equilibrium to the stable equilibrium.
8. Explain why, for any charge configuration, the equipotential surface through a point is normal to the electric field at that point.
   Draw a sketch of equipotential surfaces due to a single charge (— q), depicting the electric field lines due to the charge.
9. What is electrostatic shielding? How is th is property used in actual practice? Is the potential in the cavity of a charged conductor zero? 2
10. A charge is distributed uniformly over a ring of radius 'a'. Obtain an expression for the electric intensity E at a point on the axis of the ring. Hence show that for points at large distances from the ring, it behaves like a point charge.3

Current Electricity:

11. A resistance of R draws current from a potentiometer. The potentiometer wire, AB, has a total resistance of R_0. A voltage V is supplied to the potentiometer. Derive an expression for the voltage across R when the sliding contact is in the middle of potentiometer wire. 3



12. (i)Derive an expression for drift velocity of electrons in a conductor. Hence deduce Ohm's law. 3

(ii) How does drift velocity of electrons in a metallic conductor vary with increase in temperature? Explain. 3

13. State the two Kirchhoff s laws. Explain briefly how these rules are justified. 2
14. State the principle of working of a meter bridge. Draw the circuit diagram for finding an unknown resistance using a meter bridge. Derive the relevant formula used.
15. Two cells of emfs E_1 & E_2 and internal resistances r_1 & r_2 respectively are connected in parallel. Obtain expressions for the equivalent.
    (i) resistance and
    (ii) emf of the combination

Magnetics

16. (a) State Biot – Savart law and express it in the vector form.
    (b) Using Biot – Savart law, obtain the expression for the magnetic field due to a circular coil of radius r, carrying a current I at a point on its axis distant x from the centre of the coil. 3
17. Use Biot-Savart law to derive the expression for the magnetic field on the axis of a current carrying circular loop of radius R. Draw the magnetic field lines due to a circular wire carrying current I.
18. State Ampere's circuital law. Use this law to find magnetic field due to straight infinite current carrying wire. How are the magnetic field lines different from the electrostatic field lines? 3
19. Obtain the expression for the cyclotron frequency.
    (ii) A deuteron and a proton are accelerated by the cyclotron. Can both be accelerated with the same oscillator frequency? Give reason to justify your answer. 3
20. Show that time period of ions in cyclotron is independent of both the speed of ion and radius of circular path. What is the significance of this property?
21. Consider a beam of charged particles moving with varying speeds. Show how crossed electric and magnetic fields can be used to select charged particles of a particular velocity?
    Name another device/machine which uses crossed electric and magnetic fields. What does this machine do and what are the functions of magnetic and electric fields in this machine? Where do these field exist in this machine? Write about their natures. 5
22. Define the term magnetic susceptibility and write its relation in terms of relative magnetic permeability. 1
23. Define SI unit of current in terms of the force between two parallel current carrying conductors.

(b) Two long straight parallel conductors carrying steady currents Ia and Ib along the same direction are separated by a distance d. How does one explain the force of attraction between them ? If a third conductor carrying a current Ic in the opposite direction is placed just in the middle of these conductors, find the resultant force acting on the third conductor. 3

24. Derive an expression for the velocity v_C of a positive ions passing undeflected through a region where crossed and uniform electric field E and magnetic field B are simultaneously present. **2**

25. Describe the working principle of a moving coil galvanometer. Why is it necessary to use (i) a radial magnetic field and (ii) a cylindrical soft iron core in a galvanometer? Write the expression for current sensitivity of the galvanometer. 5

26. In what way is the behaviour of a diamagnetic material different from that of a paramagnetic, when kept in an external magnetic field?

27. How is a galvanometer converted into a voltmeter and an ammeter? Draw the relevant diagrams and find the resistance of the arrangement in each case. Take resistance of galvanometer as G.

28. Derive an expression for the axial magnetic field of a finite solenoid of length 21 and radius r carrying current I. Under what condition does the field become equivalent to that produced by a bar magnet? 3

EMI/AC

29. Can a galvanometer as such be used for measuring the current? Explain. 3

(a) Define the term 'self-inductance' and write its S.I. unit.

(b) Obtain the expression for the mutual inductance of two long co-axial solenoids S_1 and S_2 wound one over the other, each of length L and radii r_1 and r_2 and n_1, and n_2 number of turns per unit length, when a current I is set up in the outer solenoid S_2. 3

30. An a.c. source of voltage V = VO sin wt is connected to an ideal inductor. Draw graphs of voltage V and current i versus wt. 1

31. Define 'quality factor' of resonance in series LCR circuit. What is its SI unit? 1

32. Draw a labelled diagram of AC generator. Derive the expression for the instantaneous value of the emf induced in the coil.

33. Draw a labelled diagram of a step-up transformer. Obtain the ratio of secondary to primary voltage in terms of number of turns and currents in the two coils. 3

34. (a) State the principle of working of a transformer.

(b) Define efficiency of a transformer.

(c) State any two factors that reduce the efficiency of a transformer.

(d) Explain how laminating the core of a transformer helps to reduce eddy current losses in it

(e) Why the primary and secondary coils of a transformer are preferably wound on the same core 5

35. a) Draw graphs showing the variations of inductive reactance and capacitive reactance with frequency of the applied ac source.

(b) Draw the phasor diagram for a series RC circuit connected to an ac source. 3

36. In a series LCR circuit connected to an a.c. source of voltage u = um sinwt, use phasor diagram to derive an expression for the current in the circuit. Hence obtain the expression for the power dissipated in the circuit. Show that power dissipated at resonance is maximum.

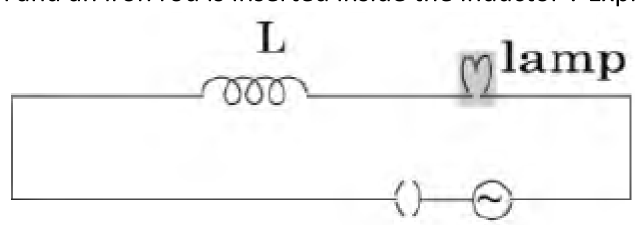
37. Show that in the free oscillations of an LC circuit, the sum of energies stored in the capacitor and the inductor is constant in time. 3

38. (i) Obtain the expression for the cyclotron frequency.

(ii) A deuteron and a proton are accelerated by the cyclotron. Can both be accelerated with the same oscillator frequency? Give reason to justify your answer. 3

39. 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.

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. 3



40. (a)Explain the meaning of the term mutual inductance. Consider two concentric circular coils, one of radius r_1 and the other of radius r_2 ($r_1 < r_2$) placed coaxially with centres coinciding with each other. Obtain the expression for the mutual inductance of the arrangement.
(b)A rectangular coil of area A, having number of turns N is rotated at ' f ' revolutions per second in a uniform magnetic field B, the field being perpendicular to the coil. Prove that the maximum emf induced in the coil is $2 \pi f NBA$. 5

EM WAVES

41. Name the electromagnetic waves that are widely used as a diagnostic tool in medicine 1
42. Why are microwaves considered suitable for radar systems used in aircraft navigation ?
43. Name the current which can flow even in the absence of electric charge. 1
44. In which situation is there a displacement current but no conduction current? 1
45. Explain why current flows through an ideal capacitor when it is connected to an a.c. source but not when it is connected to a d.c. source in a steady state.
46. How is the speed of em-waves in vacuum determined by the electric and magnetic fields? 1
47. How does Ampere-Maxwell law explain the flow of current through a capacitor when it is being charged by a battery ? Write the expression for the displacement current in terms of the rate of change of electric flux. 2
48. (i) identify the part of the electromagnetic spectrum which is :
(a) suitable for radar system used in aircraft navigation,
(b) produced by bombarding a metal target by high speed electrons.
(ii) Why does a galvanometer show a momentary deflection at the time of charging or discharging a capacitor ? Write the necessary expression to explain this observation. 3
49. How are electromagnetic waves produced ? What is the source of energy of these waves ? Write mathematical expressions for electric and magnetic fields of an electromagnetic wave propagating along the z-axis. Write any two important properties of electromagnetic waves.
50. State two properties of electromagnetic waves. How can we show that em waves carry momentum? 2

OPTICS

51. (a) With the help of a ray diagram, show how a concave mirror is used to obtain an erect and magnified image of an object.
(b) Using the above ray diagram, obtain the mirror formula and the expression for linear magnification. 3
52. Explain briefly how the focal length of a convex lens changes with increase in wavelength of incident light.
(iii) What happens to the focal length of convex lens when it is immersed in water ? Refractive index of the material of lens is greater than that of water.
53. Define the magnifying power of a compound microscope when the final image is formed at infinity. Why must both the objective and the eyepiece of a compound microscope has short focal lengths ? Explain. 2
54. Write two points to distinguish between interference and diffraction fringes. 1
55. Draw a graph showing the intensity distribution of fringes due to diffraction at single slit. 1
56. Define the power of a lens. Write its S.I. unit. 1
57. Draw a labelled ray diagram to show the image formation in a refracting type astronomical telescope in the normal adjustment position. Write two drawbacks of refracting type telescopes. 3
58. (a)Define resolving power of a telescope. Write the factors on which it depends. (b) A telescope resolves whereas a microscope magnifies. Justify the statement. 3
59. Define the magnifying power of a compound microscope when the final image is formed at infinity. Why must both the objective and the eyepiece of a compound microscope has short focal lengths ? Explain. 2
60. (i) Draw a schematic ray diagram of a compound microscope when image is formed at distance of distinct vision.
(ii) Write the expression for resolving power of a compound microscope. How can the resolving power of a microscope be increased ?
61. Define the term wave front. State Huygen's principle. Consider a plane wave front incident on a thin convex lens. Draw a proper diagram to show how the incident wave front traverses through the lens and after refraction focusses on the focal point of the lens, giving the shape of the emergent wave front. 3

62. (i)Derive Snell's law on the basis of Huygen's wave theory when light is travelling from a denser to a rarer medium.
(ii) Draw the sketches to differentiate between plane wavefront and spherical wavefront. 2

63. (a)There are two sets of apparatus of Young's double slit experiment. In set A, the phase difference between the two waves emanating from the slits does not change with time, whereas in set B, the phase difference between the two waves from the slits changes rapidly with time. What difference will be observed in the pattern obtained on the screen in the two set ups?
(b) Deduce the expression for the resultant intensity in both the above mentioned set ups (A and B), assuming that the waves emanating from the two slits have the same amplitude A and same wavelength λ. 5

64. Derive an expression for path difference in Young's double slit experiment and obtain the conditions for constructive and destructive interference at a point on the screen. 3

65. The two polaroids, in a given set up, are kept 'crossed' with respect to each other. A third polaroid, now put in between these two polaroids, can be rotated. Find an expression for the dependence of the intensity of light I, transmitted by the system, on the angle between the pass axis of first and the third polaroid. Draw a graph showing the dependence of I on ϴ.
(b) When an unpolarized light is incident on a plane glass surface, find the expression for the angle of incidence so that the reflected and refracted light rays are perpendicular to each other. What is the state of polarisation, of reflected and refracted light, under this condition? 5

66. State law of Malus.
(ii) Draw a graph showing the variation of intensity (i) of polarised light transmitted by an analyser with angle (0) between polariser and analyser.
(iii) What is the value of refractive index of a medium of polarising angle 60° ? 3
Derive the mathematical relation between refractive indices nj and np 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 principle axis in rarer medium of refractive index nj and a real image formed in the denser medium of refractive index np. Hence,erive lens maker's formula.

67. (a) When an unpolarized light of intensity Io is passed through a polaroid, what is the intensity of the linearly polarized light ? Does it depend on the orientation of the polaroid ? Explain your answer.
(b) A plane polarized beam of light is passed through a polaroid. Show graphically the variation of the intensity of the transmitted light with angle of rotation of the polaroid in complete one rotation. 3

68. What is total internal reflection ? Under what conditions does it occur ?
(ii) Find a relation between critical angle and refractive index. (iii) Name one phenomenon which is based on total internal reflection.

69. State Brewster's law. The value of Brewster angle for a transparent medium is different for light of different colours. Give reason. 2

70. Name the phenomenon on which the working of an optical fibre is based. (ii) What are the necessary conditions for this phenomenon to occur ? (iii) Draw a labelled diagram of an optical fibre and show how light propagates through the optical fibre using this phenomenon. 3

71. When a parallel beam of monochromatic source of light of wavelength λ is incident on a single slit of width a, show how the diffraction pattern is formed at the screen by the interference of the wavelets from the slit.

72. Show that, besides the central maximum at θ = 0, secondary maxima are observed at =$\left(n+\frac{1}{2}\right)\frac{\lambda}{a}$ .and the minima at θ=n$\frac{\lambda}{a}$ Why do secondary maxima get weaker in intensity with increasing n ? Explain.

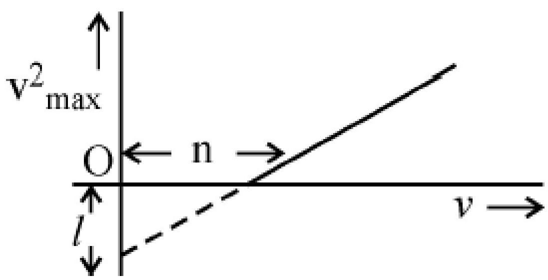
Modern Physics

73. (a) Derive the mathematical expression for law of radioactive decay for a sample of a radioactive nucleus.
(b) How is the mean life of a given radioactive nucleus related to the decay constant ?

74. Define the distance of closest approach. An α-particle of kinetic energy 'K' is bombarded on a thin gold foil. The distance of the closest approach is 'r' What will be the distance of closest approach for an a-particle of double the kinetic energy? 3

75. Find out the wavelength of the electron orbiting in the ground state of hydrogen atom. 2

76. Use Bohr model of hydrogen atom to calculate the speed of the electron in the first excited state.
77. State two important properties of photon which are used to write Einstein's photoelectric equation. Define (i) stopping potential and (ii) threshold frequency, using Einstein's equation and drawing necessary plot between relevant quantities.
78. Plot a graph showing the variation of binding energy per nucleon as a function of mass number. Which property of nuclear force explains the approximate constancy of binding energy in the range $30 < A < 170$? How does one explain the release of energy in both the processes of nuclear fission and fusion from the graph ?
79. Draw a plot showing the variation of potential energy of a pair of nucleons as a function of their separation. Mark the regions where the nuclear force is (i) attractive and (ii) repulsive. 3
80. Sketch the graphs showing variation of stopping potential with frequency of incident radiations for two photosensitive materials A and B having threshold frequencies $\nu A > \nu B$.
(i) in which case is the stopping potential more and why ?
(ii) Does the slope of the graph depend on the nature of the material used ? Explain
81. State Einstein's photoelectric equation explaining the symbols used. 3
Light of frequency ν incident is on a photosensitive surface. A graph of the square of the maximum speed of the electrons (v^2) max vs. ν is obtained as shown in the figure.



Using Einstein's photoelectric equation, obtain expressions for (i) Planck's constant (ii) work function of the given photosensitive material in terms of parameters l, n and mass of the electron m.
82. Write briefly the underlying principle used in Davison-Germer experiment to verify wave nature of electrons experimentally. What is the de-Broglie wavelength of an electron with kinetic energy (K.E.) 120 eV ?

Semiconductors

83. Distinguish between a conductor and a semi conductor on the basis of energy band diagram.
84. Write the two processes that take place in the formation of a p-n junction. Explain with the help of a diagram, the formation of depletion region and barrier potential in a p-n junction. 3
85. (i) Explain briefly the process of emission of light by a Light Emitting Diode (LED).
(ii) Which semiconductors are preferred to make LEDs and why ?
(iii) Give two advantages of using LEDs over conventional incandescent lamps
86. (a) Explain with the help of suitable diagram, the two processes which occur during the formations of a p-n junction diode. Hence define the terms (i) depletion region and (ii) potential barrier.
(b) Draw a circuit diagram of a p-n junction diode under forward bias and explain its working. 5
87. Explain with the help of a diagram the formation of depletion region and barrier potential in a pn junction.
Draw the circuit diagram of a half wave rectifier and explain its working. 3
88. Draw a labelled circuit diagram of n-p-n germanium transistor in common emitter configuration. Explain briefly, how this transistor is used as a voltage amplifier. 3
89. Draw the circuit diagram to determine the characteristics of a pnp transistor in common emitter configuration. Explain, using I-V characteristics, how the collector current changes with the base current.
How can (i) output resistance and (ii) current amplification factor be determined from the IV characteristics? 5
90. Why are photodiodes preferably operated under reverse bias when the current in the forward bias is known to be more than that in reverse bias?

The two optoelectronic devices: - Photodiode and solar cell, have the same working principle but differ in terms of their process of operation. Explain the difference between the two devices in terms of (i) biasing, (ii) junction area and (iii) I-V characteristics. 5

Communication

91. Write the function of a (i) transducer and (ii) repeater in a communication system. 1
92. Explain the terms (i) Attenuation and (ii) Demodulation used in Communication System. 1
93. Which basic mode of communication is used in satellite communication ? What type of wave propagation is used in this mode ? Write, giving reason, the frequency range used in this mode of propagation. 2
94. Define the term 'amplitude modulation*. Explain any two factors which justify the need for modulating a low frequency base-band signal. 3
95. Write the range of frequencies of electromagnetic waves which propagate through sky wave mode. 1
96. (a) Describe briefly three factors which justify the need for modulation of audio frequency signals over long distances in communication.
    (b) Draw the waveforms of (i) carrier wave, (ii) a modulating signal and (iii) amplitude modulated wave 5
97. A sinusoidal carrier wave of amplitude Ac and angular frequency ωc is modulated in accordance with a sinusoidal information signal of amplitude Am and angular frequency ωm. Show that the amplitude modulated signal contains three frequencies centered around ωc. Draw the frequency spectrum of the resulting modulated signal.3
98. Which basic mode of communication is used in satellite communication? What type of wave propagation is used in this mode ? Write, giving reason, the frequency range used in this mode of propagation. 2
99. Define modulation index. Why is it kept low ? What is the role of a bandpass filter? 2
100. Which mode of propagation is used by shortwave broadcast services having frequency range from a few MHz upto 30 MHz? Explain diagrammatically how long distance communication can be achieved by this mode.
    Why is there an upper limit to frequency of waves used in this mode? 3