Unit -1: Quantum Mechanics: Most Important Questions

Short Answer Type Questions

1. What is Planck's quantum theory?
2. Why matter waves are associated with a particle generated only it is in motion?
3. What are de-Broglie matter waves? Derive an expression for wavelength o matter waves.
4. **What are the differences between electromagnetic waves and matter waves?**
5. **What is the physical significance of the wave function?**
6. **What are the Eigen value and Eigen function?**
7. What are modified and modified radiations in Compton's scattering?
8. Explain why Compton shift is not observed with visible light?

Long Answer Type Questions

1. What is Planck's quantum theory of radiation? Discuss the Planck's radiation formula and show that the Wien's formula and the Rayleigh-Jeans are special cases of Planck's formula.
2. Discuss the de-Broglie matter waves. Describe the Davisson- Germer experiment to prove that electrons show the wave nature. Derive a relation between phase velocity and group velocity of a wave packet in a dispersive medium and show that these velocities are equal in non-dispersive medium.
3. Show that the phase velocity of de-Broglie wave is greater than the velocity of light but the group velocity is equal to the velocity of particle with which the waves are associated.
4. Derive the Schrodinger's time independent wave equation. What is the physical significance of the wave function? Or Write down Schrodinger's wave equation for a free particle in one dimensional box and solve it to find out the Eigen values and Eigen function.
5. What is Compton Effect and derive an expression for Compton shift. Explain the physical significance of the Compton shift. Explain why Compton shift is not observed with visible light and also show that the Compton shift depends only on the angle of scattering and is independent of the wavelength of the incident photon or discuss the conclusion drawn based on this effect.

Unsolved Numerical Problems

1. Calculate the de- Broglie wavelength of an alpha particle accelerated through a potential difference of 200 volts.
2. Compare the wavelength of a photon and an electron if the two have same energy.
3. A particle of rest mass m_0 has a kinetic energy K. Show that its de-Broglie wavelength is given by $\lambda = \frac{hc}{\sqrt{K(K+2m_0c^2)}}$. Hence calculate the wavelength of an electron of kinetic energy 1MeV. What will be the value of λ if $K << m_0c^2$?
4. Show that the phase velocity of de-Broglie waves associated with a moving particle having a rest mass m_0 is given by $v_p = c\left[1+\left(\frac{m_0c\lambda}{h}\right)^2\right]^{1/2}$.
5. The de-Broglie wavelength associated with an electron is 10^{-12}m. Find its group velocity and phase velocity.

6. A particle of mass m trapped in one dimensional box between with wave function $\psi = A\sin\frac{n\pi x}{L}$ in the range $0 \le x \le L$. Find the normalization form of the wave function.
7. Calculate the energy difference between the ground state and the first excited state for an electron in a one dimensional rigid box of length 10^{-8} cm or $1A^0$.
8. Calculate Compton shift if the x-rays of $\lambda = 1A^0$ are scattered from a carbon block. The scattered radiation is viewed at 90^0 to the incident beam.
9. An X-ray photon is found to have its wavelength doubled on being scattered through 90^0. Find the wavelength and energy of the incident photon.

Unit -2: Electromagnetic Theory: Most Important Questions

Short Answer Type Questions

1. What is equation of continuity? What is the physical significance of equation of continuity?
2. Why Maxwell's proposed that Ampere's law required modification?
3. What is the physical significance of Maxwell's second equation? Or Show that magnetic monopoles do not exist.
4. What is the concept of displacement current?
5. What are the similarities and dissimilarities between conduction and displacement current?
6. What is the Poynting vector? Write down the dimensions of the magnitude of Poynting vector.
7. What is skin depth, and discus its significance?

Long Answer Type Questions

1. Explain the concept of displacement current and show how it leads to the modification of Ampere's law. **Or** State Ampere's law in differential and integral forms. Discuss the modification of Ampere's law made by Maxwell's taking displacement current in consideration.
2. Write the Maxwell's equations in integral as well as in differential forms and explain their physical significance. Derive the modified Ampere's law by taking displacement current in consideration. What is the physical significance of displacement current?
3. Deduce four Maxwell's equations in free space. Prove that electromagnetic waves are transverse in nature and moving with speed of light in free space**. Or** Deduce the Wave equations for the propagation of plane electromagnetic wave in free space. Show that electromagnetic waves moving with speed of light in free space electric and magnetic fields are perpendicular to the direction of the propagation.

4. State and prove Poynting theorem for flow of energy in an electromagnetic waves and also discuss its physical significance.
5. Write down Maxwell's equation in conducting medium and use these equations to derive differential equations for electric and magnetic fields in this case. Show that the electric and magnetic fields will decrease exponentially with the distance from the surface into the conduction medium.

Unsolved Numerical Problems

1. Using the Maxwell's equation $\nabla \bullet \vec{E} = \frac{\rho}{\varepsilon_0}$, derive Coulomb's law of electrostatics.
2. A parallel plate capacitor is being charged. Show that the displacement current across an area in the region between the plates and parallel to it is equal to the conduction current.
3. In a material for which $\sigma = 5 Simen/m$ and $\varepsilon_r = 1$, the electric field intensity is $\mathrm{E} = 250\sin(10^{10}\mathrm{t})$ V/m. Find the conduction and displacement current densities and the frequency at which both have equal amplitude.
4. For a conducting medium $\sigma = 5\times10^6 Simen/m, \varepsilon_r = 1$, find the conduction and displacement current densities if the magnitude of electric field intensity E is given by $\mathrm{E} = 250\sin(10^{10}\mathrm{t})$ V/m. Also calculate the frequency at which both current densities have equal amplitude.
5. If the earth receives 2cal min^{-1} cm^{-2} solar energy, what are the amplitudes of electric and magnetic fields of radiation?
6. If the upper atmosphere layer of earth receives 1360 W/m^2 energy from the sun, what will be the peak values of the electric and magnetic fields at the layer?
7. A 100 watt sodium lamp radiating its power. Calculate the electric field and magnetic field strength at a distance 5m from the lamp.
8. If the magnitude of in plane is 1amp/ meter, find the magnitude of for plane wave in free space.
9. Calculate the depth of penetration in copper at frequency $\omega = 2\pi\times10^6 \mathrm{Hz}$ and conductivity $\sigma = 5.8\times10^7 Simen/m$ and attenuation constant (imaginary part of propagation constant).
10. Find the skin depth at frequency $\omega = 3\times10^6 \mathrm{Hz}$ in Aluminum have conductivity $\sigma = 38\times10^7 Simen/m$ and $\varepsilon_r = 1$, and attenuation constant (imaginary part of propagation constant).

Unit -3: Wave Optics: Most Important Questions

Short Answer Type Questions

1. Why two independent sources of light cannot produce interference pattern?
2. Why do you need coherent sources for observing interference pattern?
3. Why Newton's ring is circular in nature?
4. Explain the necessity of extended sources? [**Answer: An extended source is necessary to enable the eye to see whole of the film and observed the interference pattern due to whole film].**
5. Show that at the point of contact dark fringe are obtained in the case of reflected light.
6. What is the difference between Fresnel and Fraunhofer diffraction?
7. What will effect on intensity of principal maximum of diffraction pattern when single slit is replaced by double slit? [**Answer: The intensity of principal maximum of single slit diffraction pattern decreases gradually to zero but that of double slit diffraction pattern varies between certain maximum and minimum values, before attaining zero value. This happens because of superposition of interference maxima and minima on principle maximum.]**
8. Describe Rayleigh's Criterion of resolution. Write down the expression of resolution in case of a grating.
9. Define the resolving power. State Rayleigh's Criterion of resolution
10. What do you mean by dispersive power of a grating?
11. What is the resolving power of a diffraction grating?

Long Answer Type Questions

1. Discuss the phenomenon of interference of light due to thin film of uniform thickness in reflected light and find the conditions for maxima and minima. Show that the interference patterns of reflected and transmitted monochromatic source of light are complementary.
2. Discuss and explain the formation of Newton's rings in reflected monochromatic light. Prove that in reflected light diameters of the dark rings are proportional to the square root of natural number. Describe the Newton's rings method to determine the wavelength of sodium light.

3. Explain the phenomenon of diffraction and distinguish Fresnel and Fraunhofer diffraction. Obtain intensity of diffraction pattern in Fraunhofer diffraction due to a single slit. Show that the relative intensities of successive maxima are nearly $1: \frac{4}{9\pi^2} : \frac{4}{25\pi^2} :$
4. What do you understand by missing order of spectrum? What particular spectra would be absent if the width of the transparencies and opacities of the grating are equal. Show that only first order spectra is possible if the width of the grating element is more than wavelength of light and less than twice the wavelength of light.
5. What do you understand by dispersive power of grating? Show that dispersive power of grating can be expressed as $\frac{1}{\sqrt{\left(\frac{e+d}{n}\right)^2 - \lambda^2}}$ where all terms have their usual meanings.
6. What do you understand by the limit of resolution (or resolving power) power of a grating? Derive an expression for the resolving power of a grating.

Unsolved Numerical Problems

1. A film of refractive index (μ) is illuminated by white light at an angle of incidence i. In reflected light two consecutive bright fringes of wavelength λ_1 and λ_2 are found overlapping. Obtained an expression for the thickness of the film.
2. **A thin film of soap solution is illuminated by white light at an angle of incidence, $i = \sin^{-1} 4/5$. In reflected light two dark consecutive overlapping fringes are observed corresponding to wavelength 6.1×10^{-7} m. The refractive index for soap is $4/3$. Calculate thickness of the film.**
3. **Light of wavelength** $6000A^0$ **falls normally on a thin wedge shaped film of refractive index 1.4 forming fringes that are 2.0mm apart. Find the angle of wedge in seconds.**
4. A square piece of cell phone film with refractive index 1.5 has a wedge shaped section so that its thickness at two opposite sides is t_1 and t_2. If the number of fringes appearing with wavelength $\lambda = 6000A^0$ is 10, calculate the difference $(t_2 - t_1)$.
5. **Newton's rings are observed normally in reflected light of wavelength** $\lambda = 6000A^0$**. The diameter of the 10th dark ring is 0.50cm. Fid the radius of curvature of the lens and the thickness of the film.**
6. **Newton's rings are observed by keeping a spherical surface of 100cm radius on a plane glass plate. If the diameters of the 15th bright ring is 0.590 cm and the diameter of the 5th ring is 0.336cm, what is the wavelength of light used?**

7. **In Newton's ring experiment the diameter of 4^{th} and 12^{th} dark rings are 0.400 cm and 0.700cm respectively. Deduce the diameter of 20^{th} dark ring.**
8. Newton's rings are formed in reflected light of wavelength $\lambda = 6000A^0$ with a liquid between the plane and curved surfaces. If the diameter of 6^{th} bright ring is 3.1 m and the radius of curvature of the curved surface is 100cm, calculate the refractive index of the liquid.
9. A diffraction grating used at normal incidence gives a green line (5400 Å) in certain order superimposed on the violet line (4050 Å) of the next higher order. If the angle of diffraction is 30^o, how much lines per cm are there in the grating?
10. A single slit is illuminated by light composed of two wavelengths λ_1 and λ_2. One observe that due to Fraunhofer diffraction, the first minima obtained for λ_1 coincides with the second diffraction minima of λ_2. What is the relation between λ_1 and λ_2?
11. How many orders will be visible if the wavelength of incident radiation $5000A^0$ and the number of lines on the grating is 2620 to an inch?
12. Monochromatic light from He-Ne laser of wavelength $6328A^0$ is incident normally on a diffraction gratin 6000 lines/cm. Find the angles at which one would observe the first order maximum, the second order maximum.
13. What must be minimum number of lines per cm in a half inch width grating to resolve the wavelength 5890Å and 5896Å?
14. Find the minimum number of lines in a plane diffraction grating required to just resolve the sodium doublet be resolved (for 5890Å and 5896Å) in first and second orders.
15. A plane transmission grating has 15000 lines per inch. Find the resolving power of the grating and the smallest wavelength difference that can be resolved by a light of wavelength 6000 Å in the second order. Hint: $\text{R. P.} = \frac{\lambda}{d\lambda} = n\,N \text{ or } d\lambda = \frac{n\,N}{\lambda}$
16. Can D_1 and D_2 lines of sodium light be resolved (for $\lambda_{D_1} = 5890$ Å and $\lambda_{D_2} = 5896$ Å) in second order. Number of lines in grating of 2.0 cm wide = 4500.
17. Obtain the design of a plane transmission diffraction grating capable a wavelength difference of $6A^0$ at a mean wavelength 6000 Å in second order spectra.

Unit-4: Fiber Optics and Lasers

Short Answer Type Questions

1. Describe the basic principle of an optical fiber.
2. What are the main components of optical fiber?
3. What are the differences between step index and graded index fibers?
4. What is the numerical aperture (NA)?
5. What do you mean attenuation in optical fiber?
6. Why modal dispersion is negligible in single mode optical fiber?
7. What are the applications of optical fibers?
8. What is difference between spontaneous emission and stimulated emission of radiation?
9. Why spontaneous emission is incoherent?
10. Why two level laser systems does not have any physical significance?
11. What is the role of metastable state to achieve the population inversion?
12. What is the population inversion? Or why population inversion is necessary for laser beam?
13. What are the components of laser systems?
14. What are the properties of laser beam? What are the special characteristics of laser?
15. How you can say that He-Ne laser is superior to Ruby laser?

Long Answer Type Questions

1. Describe the propagation mechanism and communication in optical fibers. Also discuss about the signal loss in optical fibers.
2. Explain the single mode and multi-mode fiber. What are the advantages of optical fiber over copper wire?

3. Explain acceptance angle and acceptance cone of an optical fiber. What do you mean by numerical aperture of an optical fiber? Derive the expression for numerical aperture for optical fiber.
4. What is the principle of optical fiber? Discuss the different types of optical fibres. What are advantages of optical fiber over a copper wire?
5. What do you understand by attenuation in optical fiber? Discuss the important factors responsible for the loss of power in optical fiber.
6. What are techniques used for population inversion? Or what is the pumping? Describe the various pumping mechanism to achieve the population inversion.
7. What are the necessary conditions to achieve to laser action?
8. What are the differences between spontaneous and stimulated emissions? Which one out of these two processes, is maximized in case of laser action, give suitable justification to your answer.
9. What are the Einstein's coefficients? Derive Einstein's relation between them. Also discuss the essential conditions for laser action.
10. What are the Einstein's coefficients? Derive Einstein's relation between them. Discuss the construction and working of He-Ne laser and important applications. How it is superior to Ruby laser.
11. Explain the principle of laser and describe working of Ruby laser. What are the characteristics of laser beam? Why He-Ne laser superior than Ruby laser.
12. Discuss the construction and working of Ruby laser with help of a well labeled diagram. What are the important applications?

Numericals

1. A silica glass optical filter has a core refractive index of 1.500 and cladding refractive index of 1.450. Calculate the numerical aperture of the fiber.
2. Calculate the numerical aperture, acceptance angle and critical angle of the fiber from the following data: core refractive index=1.50 and cladding refractive index= 1.45.
3. If the fractional difference between the core and cladding refractive indices of a fiber is 0.0135 and numerical aperture (NA) is .2425, calculate the refractive indices of the core and cladding materials

4. A signal of 100mW is injected into a fiber. The out coming signal from the other end is 40 mW. What is the attenuation loss in decibels (dBs)?

5. An optical fiber of length150m has input power 10μW and output power of 9μW. Compute loss in dB/km.

6. A communication system uses a10km fiber having a loss of 2.5dB/km. Compute the output power if the input power is 500μW.

7. The mean optical power launched into a 4-km long optical fiber is 120 μW. The mean power reaching the end of the fiber is 4 μW. Calculate the attenuation constant of the fiber.

8. A communication system uses a 25km long fiber having a loss of 2.5 dB/km. The input power is 2500 μW, compute the output power.

9. Calculate the energy and momentum of a photon of a laser of a laser beam of wavelength 6328Å.

10. A gas laser is generating a laser beam of 4 mW power. Calculate the number of photons emitted by the laser. The wavelength of the emitted radiation is 680nm.

11. A certain ruby laser emits 1J pulses of light whose wavelength is 6940 Å. What is the minimum number of Cr^{+3} ions in the ruby?

12. Calculate the population ratio of two states in He-Ne laser that produces light of wavelength 6000 Å at 300 K.

13. The ratio of population of the energy level is 1.059×10^{-30}. Find the wavelength of light emitted at 300 K.

14. An atom has two atomic levels separated by 2.26 eV in energy. At what temperature would the ratio (N2/N1) is half?