CHAPTER-11

DUAL NATURE OF RADIATION AND MATTER

One mark questions

1. Who discovered cathode rays? (K)
2. Name the scientist who has confirmed cathode ray hypothesis of William Crookes. (K)
3. Which observation with respect to cathode ray particles suggested universality of cathode rays? (K)
4. Who named cathode ray particles as electrons? (K)
5. Who suggested that the electrons are fundamental constituents of matter? (K)
6. Who experimentally proved that the electric charge is quantized? (K)
7. The determination and measurement of the value of elementary charge credit goes to which experimental work? (K)
8. Define work function of a photo sensitive material. (U)
9. Define electron volt. (U)
10. What is thermionic emission? (K)
11. What is field emission? (K)
12. Why metals are preferred for electron emission? (U)
13. Who discovered the phenomenon of photo electric emission? (K)
14. What is photo-electric emission? (K)
15. What are photo electrons? (K)
16. What is photo electric effect? (K)
17. Name the phenomenon which illustrates the particle nature of light. (K)
18. Can radiation of any frequency be used for electron emission from a metal surface? (K)
19. How photo current depends on intensity of incident radiation? (K)
20. Represent graphically the variation of photoelectric current with intensity of incident light. (S)
21. Do stopping potential depends on the intensity of incident radiation? (K)
22. Define threshold frequency for a photo sensitive metal. (U)
23. What is the effect of intensity of incident radiation on kinetic energy of photoelectrons? (K)
24. Why threshold frequency is different for different metals? (U)
25. In an experiment of photo electric effect a graph of kinetic energy of photoelectrons with frequency of incident light is plotted. What does the slope of the curve indicate? (U)
26. What is meant by saturation current in photo electric emission? (U)
27. In an experiment of photo electric effect the kinetic energy of photo electrons is found to be 2 eV. for certain intensity of incident light. If the intensity of incident light is doubled what will be the kinetic energy of photo electrons? (A)
28. How does the velocity of photo electrons emitted vary with frequency of incident light on a photo cathode? (U)
29. What is the significance of stopping potential of a photo sensitive material? (U)
30. How does the stopping potential vary with frequency of incident radiation? (U)

31. Name the theory which explains the phenomenon of photo electric emission. (K)
32. Which physical constant can be determined from the slope of the graph of maximum kinetic energy of photo electrons with the frequency of incident radiation? (U)
33. What is the charge on photons? (K)
34. Are photons deflected by electric and magnetic fields? (K)
35. Material particle collides with photons, do the momentum is conserved? (K)
36. In a collision between photon and particle, is energy conserved? (K)
37. Do the photon number is conserved in the process of collision between the particle and photon? (K)
38. Who postulated the dual nature of matter? (K)
39. What are matter waves? OR what are de Broglie waves? (K)
40. State de-Broglie hypothesis of matter waves. (K)
41. Define de-Broglie wavelength. (U)
42. How does the de-Broglie wavelength of an electron depend on its velocity? (U)
43. A particle accelerates under the influence of an electric field. What happens to its de-Broglie wavelength? (U)
44. Write the expression for the de-Broglie wavelength of an electron accelerated through a potential difference of V volts? (K)
45. Who discovered the wave nature of electron? (K)
46. Name the experiment which confirms the wave nature of material particle. (K)
47. State Heisenberg's uncertainty principle. (K)
48. Write the mathematical equation representing Heisenberg's uncertainty principle. (K)
49. What was the outcome of Davisson and Germer experiment? (K)
50. Mention one application of wave property of electrons. (K)
51. Mention one advantage of using the electron microscope over the optical microscope. (U)

Two mark questions

1. Mention the two discoveries which are the milestones in understanding atomic structure. (K)
2. Explain how cathode rays were discovered by William Crooke. (U)
3. What was the inference of Millikan's oil drop experiment? (U)
4. Name any two types of electron emission. (K)
5. Mention two factors on which the photo electric work function of a metal depends? (K)
6. Mention the Hertz's observations on photo electric effect. (U)
7. Why Alkali metals are photo sensitive even to visible light? (U)
8. Define "Stopping potential". How does it depend on the frequency of incident radiation? (U)
9. Graphically show the variation of photo electric current with intensity of incident light. (S)
10. Show graphically, the variation of photo current with stopping potential for different frequencies but same intensity of incident radiation. (S)
11. Represent graphically the variation of photo current with collector plate potential for different intensity of incident radiation. (S)
12. Draw the graph representing the variation of stopping potential with frequency of incident radiation for a given photo sensitive material. (S)

13. What was the picture given by Einstein about electromagnetic radiation to explain photo electric effect? (U)
14. Write Einstein's photo electric equation and explain the terms. (K)
15. Mention the expression for de-Broglie wavelength of matter waves and explain the terms.(K)
16. Mention the expression for de-Broglie wavelength of photon and explain the terms. (K)
17. Mention the expression for de- Broglie wavelength of a material particle in terms of kinetic energy and explain the terms. (K)
18. A proton and an α-particle are accelerated by the same potential difference. Compare their de-Broglie wavelength. (U)
19. Find the de-Broglie wavelength of an electron having a kinetic energy of 500eV. (A)
20. Are matter waves electromagnetic in nature? Justify your answer. (U)
21. Why de-Broglie wavelength associated with macroscopic particles cannot be detected? Explain. (U)
22. Calculate the de-Broglie wavelength of a particle of mass 0.05 kg moving with a speed of $100ms^{-1}$. (A)
23. What is Born's probability interpretation of matter waves? (U)

Three mark questions

1. Who discovered the phenomena of photo electric emission? Explain how he discovered this phenomenon? (K)
2. Explain briefly Hallwach's experimental observations on photo-electric effect. (K)
3. Explain briefly the Lenard's experimental observations on photo electric effect. (K)
4. Describe the experiment to study the photo electric effect. (K)
5. Define the terms
   (i) Threshold frequency **(ii)** Threshold wavelength **(iii)** Stopping potential, with reference to photo electric effect. (U)
6. Explain why wave theory of light failed to explain photoelectric effect observations. (U)
7. Write three observed features of photoelectric effect which cannot be explained by wave theory of light. (U)
8. State de-Broglie's hypothesis of matter waves. What was the reason for stating this hypothesis? (U)
9. Show that the wavelength of photon $\lambda = \frac{h}{p}$ where h=Planck's constant and p=momentum of photon. (U)
10. Obtain the expression for de-Broglie wavelength in terms of accelerating potential. (U)
11. Derive the expression for de-Broglie wavelength in terms of kinetic energy of electrons. (U)
12. Describe Davisson and Germer experiment to establish the existence of wave nature of electron. (U)
13. Write the applications of de-Broglie's hypothesis of matter waves. (K)

Five mark questions

1. What were the observations of Hallwach's and Lenard's about photo electric emission? (K)
2. Describe the experiment to study photo electric effect with a neat labeled diagram. (U) (S)
3. Write the experimental observations of photo electric effect. (U)

4. Give Einstein's explanation for photo electric effect experimental observations. (U)
5. Give the photon picture of electromagnetic radiation. (U)
6. Mention five characteristic properties of photon. (K)
7. Describe Davisson and Germer electron diffraction arrangement with a neat labeled diagram. (U) (S)

Numerical problems

1. Calculate the number of photons emitted per second by a 25W source of monochromatic light of wavelength 600nm. (A) **[$7.546X10^{19}$]**

2. The threshold wavelength of a photo sensitive metal is 275 nm. Calculate the maximum velocity of the photo electrons ejected when light of 180nm incident on it. (A) **[$9.1X10^{5} ms^{-1}$]**
3. Lithium has work function of 2.3eV. It is exposed to light of wavelength $4.8X10^{-7}$m. Find the maximum kinetic energy with which electron leaves the surface. Also calculate the longest wavelength which can produce the photoelectrons. (A)
4. The threshold frequency is of a photosensitive metal is $0.5X10^{15}$Hz, Calculate the photoelectric work function of the metal. If a photon of frequency 0.75×10^{15}Hz incident on this metal surface, find the maximum kinetic energy (in eV) of photoelectrons emitted. (A)
   [W = 2.072eV, $K.E_{max}$ = 1.036eV]
5. The photo electric threshold for a metal surface is 600nm. Calculate the maximum kinetic energy (in eV) of the photoelectrons emitted for radiation of wavelength 400nm. (A) **[$(K.E)_{max}$ = 1.04eV)**
6. The work function of cesium is 2.14eV. Find (a) the threshold frequency for cesium and (b) the wavelength of the incident light if the photocurrent is brought to zero by a stopping potential of 0.60V. (A) **[$\gamma_0 = 5.16 \times 10^{14}$ Hz, λ = 454nm]**

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