PHYSICS

BOOKS - MODERN PUBLICATION

Wave Nature of Matter

Example

1. What is de-Broglie waveelngth of a 3 kg object moveing with a speed of $2ms^{-1}$?

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2. Calculate the de-Broglie waveelngth of an electron of energy 400 eV.Given,lanck's constant = $6.6 \times 10^{-34} Js$, mass of electron $= 9.1 \times 10^{31} kg, 1eV = 1.6 \times 10^{-19} J.$

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3. Calculate the de-Bronglie waveelngth for electron and protonif their speed is $10^5 ms^{-1}$ .Given,mass of an electron $= 9.1 \times 10^{-31} kg$

,mass of proton = $1.67 \times 10^{-27} kg$ and Planck's constant = $6.62 \times 10^{-34} Js$.

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4. A particle of mass M at rest decays into two particles of masses m_1 and m_2 havibng non zero eloctities.What is the ratio of the de-Bronglie waveelngths of the two particles?

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5. X-rays of wavelength λ fall on an phtot senstive surface,emitting electrons.Assuming that the work function of the surface can be netglected,prove that the de-Broglie wavelength of electrons emited will be $\sqrt{h\lambda/(2mc)}$.

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6. Mention the significance of Davisson and Germer's experiment. An $\alpha - particle$ and a proton are accelerated from rest through the same potential difference V. find the ratio of de-Broglie wavelength associated with them.

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7. Which of the following has the largest de Broglie wavelength (all have eual velocity)?

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8. Obtain de-Broglie waveelngth of an electon of kinetic energy 150 eV.Given mass of electron,$m = 9.1 \times 10^{-31} kg$,charge on electron, $e = 1.6 \times 10^{-19} C$ and Planck's constant ,$h = 6.62 \times 10^{-34} Js$.

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9. Find de-Broglie wavelength of neutron at $127^\circ C$.Given,Boltzmann's constant k=1.38 $\times$

10^{-23} $Jmol^{-1}$ k^{-1},h = 6.625 $\times$ 10^{-34} Js and mass of neutron =$1.66 \times 10^{-27} kg$.

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10. What is the de-Broglie wavelength of an electron beam accelerated through a potential difference of 25 V?

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11. What voltage must be applied to an elecron microscope to produce electrons of wavelength $0.4\overset{\circ}{A}$?

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12. An electron microscope uses electron accelerated by a voltage of 50kV. Determine the de-Broglie wavelengths associated with the electrons. If other factors (such as numerical aperture etc) are taken to be roughly the same how does the resolving power of electron microscope compare with that of an optical microscope which uses yellow light?

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13. Assume that the de Broglie wave associated with an electron can from a standing wave between the atom arrange in a one dimensional array with nodes at each of the atomic sites. It is found that one such standing wave if the distance d between the atoms of the array is $2A^0 A$similar standing wave is again formed if d is increased to $2.5\AA$. Find the energy of the electrons in electron volts and the least value of d for which the standing wave type described above can from .

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14. In a photoelectric effect set up, a point source of light of power 3.2×10^{-3} W emits monoenergetic photons of energy 5eV.The source is located at a distance of a stationary metallic sphere of work function 3eV and radius $8 \times 10^{-3} m$.The efficiency of photoelectron emission is one for every 10^6 incident photons.Assume that the sphere is isolated and initially neutral and the photoelectrons are initially swept away after emission.

Calculate the number of photoelectrons emitted per second.

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15. In a photoelectric effect set up, a point source of light of power 3.2×10^{-3} W emits monoenergetic photons of energy 5eV.The source is located at a distance of a stationary metallic sphere of work function 3eV and radius $8 \times 10^{-3} m$.The efficiency of photoelectron emission is one for every 10^6 incident photons.Assume that the sphere is isolated and initially neutral and the photoelectrons are initially swept away after emission.

Find the ratio of the wavelength of incident light to the de Broglie wavelength of the fastest phtotelectrons emitted.

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16. Photon is not a material particle. (True/ false)

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17. What is the momentum of a photon of frequency v?

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18. Write down the relation betwen the energy and the momentum of a photon.

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19. An elecrtron is acelerated through a potential difference of 300 V.What is its energy in electron volt?

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20. What is the rest mass of a photon?

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21. What led to the discovery matter waves?

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22. Show that the wavelength of electromagnetic radiation is equal to the de-

Broglie wavelength of its quantum (Photon).

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23. Are matter waves electromagnetic?

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24. What information is derived from electron diffraction experiments?

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25. Derive the expression for de Broglie wavelength associated with an electron in a potential differences of V volts.

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26. A proton and α-particles are aceelerated through the same potential difference. The ratio of their de-Brogile wavelength will be:

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27. With what purpose was famous Davisson Germer experiment with electrons performed?

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28. With what purpose was famous Davisson Germer experiment with electrons performed?

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29. What are those structers which appear as "beads- on -string" in the chromosomes whne viewed under electron microscope?

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30. Show that de-Broglie hypothesis of matter wave supports the Bohr's concept of stationary orbit.

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31. Discuss dual nature of radiations.

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32. Discuss dual nature of radiations.

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33. Derive de Broglie's equation.

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34. Find the momentum of a photon of wavelength $0.01\overset{\circ}{A}$.

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35. Calculate momentum of electron, if their wavelength is $2\overset{\circ}{A}$. Given, Planck's constant $h = 6.625 \times 10^{-34} Js$, mass of electron $m = 9.1 \times 10^{-31}$kg.

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36. Calculate the de-Broglie wavelength for electron moving with speed of $6 \times 10^5 ms^{-1}$.

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37. Why is wave nature of matter not apparent to our daily observations?

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38. Why are de-Broglie waves with a moving football not visible?

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39. Calculate de Broglie's wavelength associated with an electron moving with a velocity equal to $1/10th$ of light.

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40. What is the de-Broglie wavelength of a dust particle of mass $1.0 \times 10^{-9} kg$ drifting with a speed of 2.2 m/s?

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41. An electron and a photon each have a wavelength of 1.00 nm. Find

their momenta?

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42. An electron and a photon each have a wavelength of 1.00 nm. Find

the energy of the photon?

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43. An electron and a photon each have a wavelength of 1.00 nm. Find

the kinetic energy of electron.

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44. The de-Broglie wavelengths,associated with a proton and a neutron,are found to be equal.Which of the two has a higher value for kinetic energy?

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45. Electron and proton are moving with the same speed, which will have more wvalength?

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46. Mention the significance of Davisson and Germer's experiment. An $\alpha - particle$ and a proton are accelerated from rest through the same potential difference V. find the ratio of de-Broglie wavelength associated with them.

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47. The elements Li, Na and K, each having one valence electron, are in period 2, 3 and 4 respectively of modern periodic table.

Which one of them is least rea-ctive ?

Give reason to justify your answer in each case.

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48. Mention the significance of Davisson and Germer's experiment. An $\alpha - particle$ and a proton are accelerated from rest through the same potential difference V. find the ratio of de-Broglie wavelength associated with them.

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49. An electron and alpha particle have the same de-Broglie wavelength associated with them. How are their kinetic energies related to each other?

Watch Video Solution

50. Mention the significance of Davisson and Germer's experiment. An $\alpha - particle$ and a proton are accelerated from rest through the same potential difference V. find the ratio of de-Broglie wavelength associated with them.

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51. A proton and α-particles are aceelerated through the same potential difference. The ratio of their de-Brogile wavelength will be:

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52. A photon and an electron have got same de Brogile wavelength. Which has greater total energy? Explain.

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53. Mention the significance of Davisson and Germer's experiment. An $\alpha - particle$ and a proton are accelerated from rest through the same potential difference V. find the ratio of de-Broglie wavelength associated with them.

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54. An electron and a proton have equal momentum. Which has more kinetic energy and what is the ratio between the kinetic energy of electron and proton?

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55. An electron and alpha particle have the same de-Broglie wavelength associated with them. How are their kinetic energies related to each other?

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56. A photon and an electron have got same de Brogile wavelength. Which has greater total energy? Explain.

Watch Video Solution

57. A photon and an electron have got same de Brogile wavelength. Which has greater total energy? Explain.

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58. A electron is accelerated through a potential difference of 100V. What is de-Broglie wavelength associated with it? To which part of the electromagnetic spectrum does this value of wavelength correspond?

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59. The de-Broglie wavelength associated with an electron accelerated through a potential difference V is λ. What will be wavelength when accelerating potential is increased to 4V?

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60. Show graphically,the variation of the de-Broglie wavelength (λ) with the potential 9V) through which an electron is accelerated from rest.

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61. A proton and α-particles are aceelerated through the same potential difference. The ratio of their de-Brogile wavelength will be:

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62. Find the of de-Broglie wavelengths associated with

(i) protons, accelerated through a potential of 128 V, and

(ii)α- particles accelerated through a potential difference of 64 V.

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63. Find the of de-Broglie wavelengths associated with

(i) protons, accelerated through a potential of 128 V, and

(ii)α- particles accelerated through a potential difference of 64 V.

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64. Calculate the ratio of the accelarating potential required to accelrate

a proton and and alpha particle to have the same de-Broglie wavelength associated with them

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66. Calcualte the ratio of the accelerating potential requied to accelrate a deutron and alpha particle to have the same de-Broglie wavelength assoiated with them.Given,mass of deutron =$3.2 \times 10^{-27} kg$ and mass of alpha particle = $6.4 \times 10^{-27} kg$.

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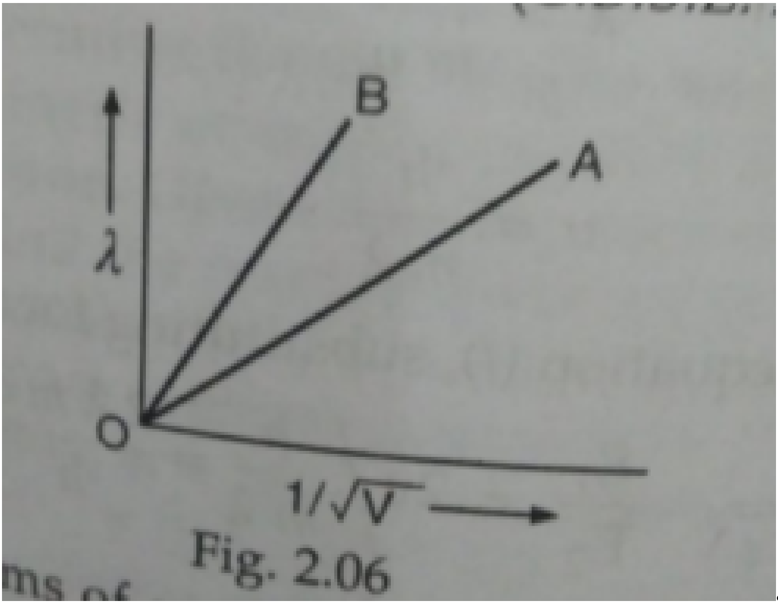
67. The two lines marked A and B in Fig.2.96 show a plot of de-Broglie wavelength (λ) as a function of $1/\sqrt{V}$ (V is the acceleratijng potential)j for two nuclei $\_1H^2$ and $\_1H^3$.

What does the slope of the lines represent?



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68. The two lines marked A and B in Fig.2.96 show a plot of de-Broglie wavelength (λ) as a function of $1/\sqrt{V}$ (V is the acceleratijng potential)j for two nuclei $_1H^2$ and $_1H^3$.

Identify,which lines correspond to these nuclei?

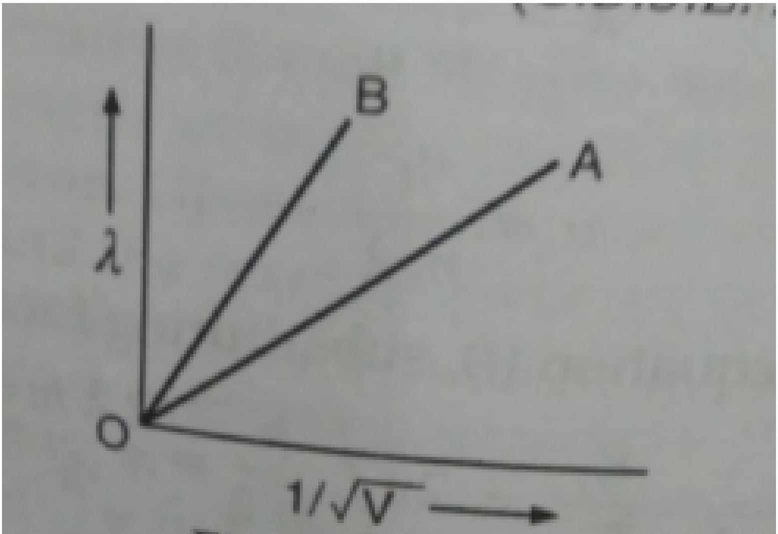

Fig. 2.06

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69. The two lines A nad B in Fig.2.06 show the plot of de-Broglie wavelength (λ) as a function of $1/sqtV$ (is the accelertaing potential) for two particles having the same charge.Which of the two represents the particle sof heavier mass?

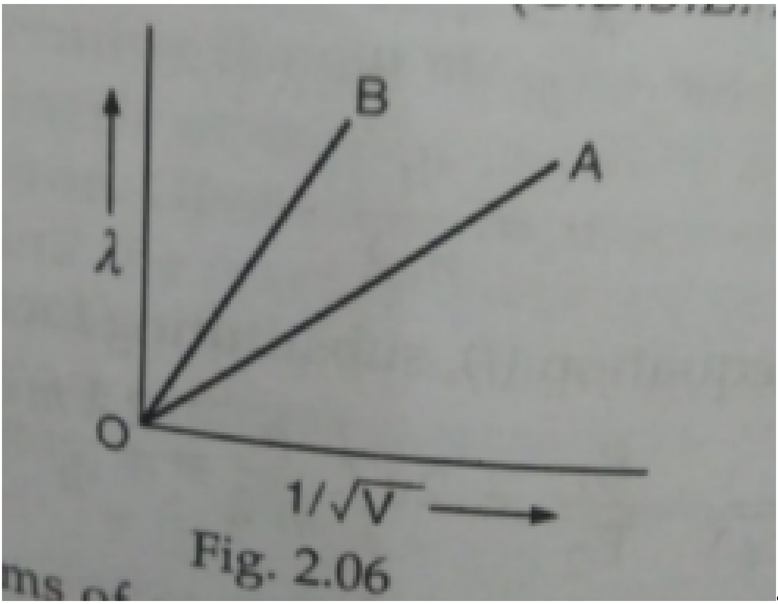

Fig. 2.06

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70. The de-Broglie wavelength of a particle of kinetic enregy K is λ .What would be the wavelength of the psarticle,if its kinetic energy were $k / 4$?

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71. An electron and alpha particle have the same de-Broglie wavelength associated with them. How are their kinetic energies related to each other?

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72. An electron and alpha particle have the same de-Broglie wavelength associated with them. How are their kinetic energies related to each other?

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73. A proton and α-particles are aceelerated through the same potential difference. The ratio of their de-Brogile wavelength will be:

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74. A proton and α-particles are aceelerated through the same potential difference. The ratio of their de-Brogile wavelength will be:

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75. An electron and a photon each have a wavelength of 1.00 nm. Find their momenta?

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76. The de-Broglie wavelength of a photon is the same as the wavelength of electron, show that kinetic energy of photon is $\frac{2mc\lambda}{h}$ times the kinetic energy of electron, where m is the mass of electron and c is the velocity of light.

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77. An electromagnetic wave of length λ is incident on a photosensitive surface of negligible work function. If the photoelectrons emitted from the surface have the same de-Broglie wavelength λ, prove that $\lambda = \frac{2mc}{h}\lambda_1^2$

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78. Calculate the potential difference through which an electron, initially at rest, must be

accelerated so that its de Broglie wavelength is equal to 0.40 nm.

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79. Determine the de-Broglie wavelength of a proton, whose kinetic energy is equal to the rest mass energy of an electron. Given that the mass of an electron is 9.1×10^{-31} kg and the mass of a proton is 1,837 times as that of the electron.

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80. Show that de-Broglie hypothesis of matter wave supports the Bohr's concept of stationary orbit.

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81. Obtain the de-Broglie wavelength associated with thermal neutrons at room temperature $(27^\circ C)$. Hence explain why a fast neutron beam needs to be thermalized with the environment before it can be used for neutron diffraction experiments.

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82. The extent of localisation of a particle is determined roughly by its de-Broglie wave.If an electron is loclalized within the nucleus (of size about 10^(-14)m) of an atom,what is its energy?Compare this energy with the typicla binding energyies(of the order of a few Me) in a nucleus and hyence argue why electrons cannot reside in a nucleus.

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83. A parallel beam of electrons,all travelling at the same speed,is incident normally on a carbon film.The scattering of the electrons by the film is observed on a fluorescent screen, as illustrated in Fig.2.07.

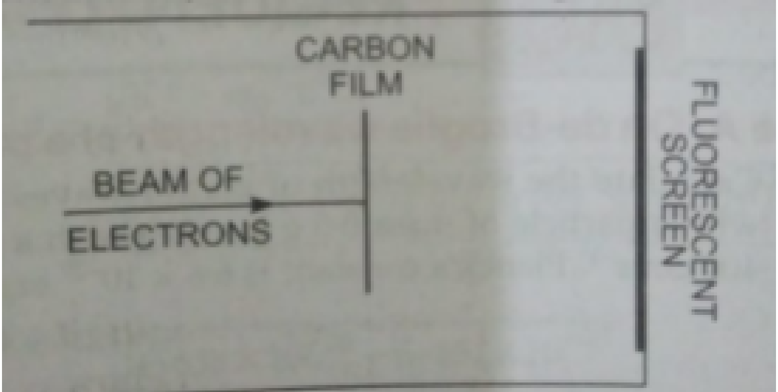

Fig. 2.07

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Assuming that the electrons behaves as particles, predict what would be seen on the screen.

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84. A parallel beam of electrons,all travelling at the same speed,is incident normally on a carbon film.The scattering of the electrons by the film is observed on a fluorescent screen, as illustrated in Fig.2.07.

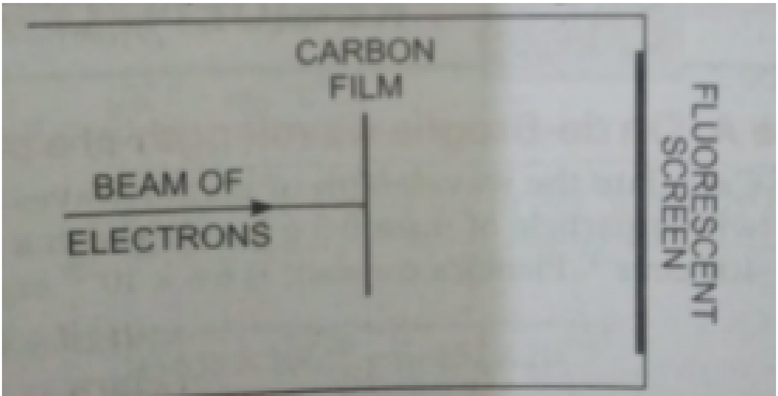

Fig. 2.07

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In this experiment,the elctrons do not behave as particles.Describe breifly the patten that is actually observed on the screen.you may draw a sketch,if you wish.

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85. A parallel beam of electrons,all travelling at the same speed,is incident normally on a carbon film.The scattering of the electrons by the film is observed on a fluorescent screen, as illustrated in Fig.2.07.

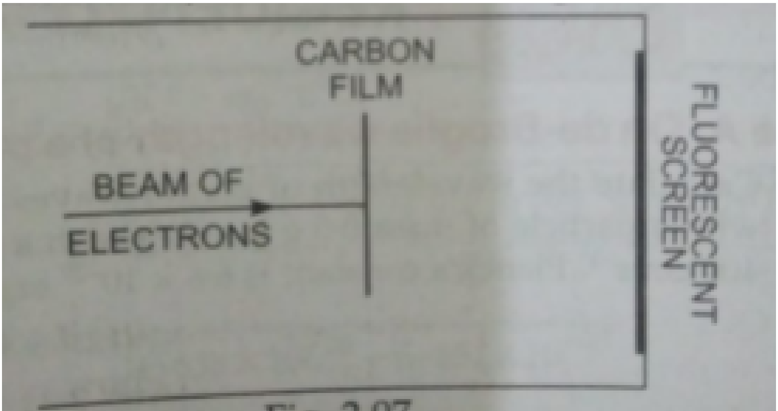

Fig. 2.07

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The speed of the electrons is gardually increased.State and explain what change,if any , is observed in the pattern on the screen.

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86. A photon and an electron have got same de Brogile wavelength. Which has greater total energy? Explain.

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Exercise

1. What is photons? Prove that its rest mass is zero.

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2. Are matter waves electromagnetic?

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3. Write de Brogile hypothesis for matter wave and find an expression for de-Broglie wave length.

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4. Write de Brogile hypothesis for matter wave and find an expression for de-Broglie wave length.

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5. What do you men by dual nature of matter ?

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6. Derive de Broglie's equation.

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7. Calculate the de-Brogile wavelength of an electron.

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8. Find the de Brogile wavelength associated with an electron accelerated under a potential difference of 100 V.

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9. Show that the de-Broglie wavelength λ of electrons of energy E is givne by the relation:

$$\lambda = \frac{h}{\sqrt{2mE}}.$$

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10. Derive the expression for de Broglie wavelength associated with an electron in a potential differences of V volts.

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11. Show that de-Broglie hypothesis of matter wave supports the Bohr's concept of stationary orbit.

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12. Derive the expression for de Broglie wavelength associated with an electron in a potential differences of V volts.

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13. Explain the dual behaviour of matter.

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14. Describe an experiment which shows the wave nature of electron.

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15. Calculate the wavelength of matter waves associated with a particles of mass 0.5 g moving with a velocity of $400cms^{-1}$ Planck's constant is $6.6 \times 10^{-27}ergs$.

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16. Deterine de-Brogile wavelength associated with a ball of mass 150 g travelling at $30ms^{-1}$.

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17. Find de Broglie wavelength of wave associated with a particle of rest mass $5 \times 10^{-30} kg$ and moving with a speed $1.8 \times 10^{8} ms^{-1} (h = 6.6 \times 10^{-34} Js)$.

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18. Is it possible to observe de -Broglie wave associated with a material particle of 10^{-4} g moving with the velocity of light?Planck's constant is 6.6×10^{-27} erg s.

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19. the de-Brolie wavelength of an electron is $2\overset{\circ}{A}$.Calculate its momneum .Planck's constant is $6.6 \times 10^{-27} ergs$.

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20. Find the wavelength for a beam of neutrons,whose kinetic energy is 100 eV.Given that mass of neutron = $1.676 \times 10^{-24} g$ and $h = 6.62 \times 10^{-27} ergs.$.

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21. Obtain de-Broglie waveelngth of an electon of kinetic energy 150 eV.Given mass of electron,$m = 9.1 \times 10^{-31} kg$,charge on electron, $e = 1.6 \times 10^{-19} C$ and Planck's constant ,$h = 6.62 \times 10^{-34} Js$.

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22. What is the de-Broglie wavelength of an electron with kinetic energy of 120 eV?

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23. What is the

de Broglie wavelength

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24. What is the momentum of an electron of energy 100 eV?

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25. Find de-Broglie wavelength associated with a proton of energy 2 MeV. Given, mass of proton is $1.67 \times 10^{-27} kg$.

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26. Obtain de-Broglie waveelngth of an electon of kinetic energy 150 eV.Given mass of electron,$m = 9.1 \times 10^{-31} kg$,charge on electron, $e = 1.6 \times 10^{-19} C$ and Planck's constant ,$h = 6.62 \times 10^{-34} Js$.

Watch Video Solution

27. Find de-Broglie wavelength of neutron at $127^{\circ} C$.Given,Boltzmann's constant k=1.38 $\times 10^{-23} Jmol^{-1} k^{-1}$,h = 6.625 $\times$ 10^{-34} Js and mass of neutron =$1.66 \times 10^{-27} kg$.

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28. What is the de-Broglie wavelength of an electron beam accelerated through a potential difference of 25 V?

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29. Calculate the de-Brogile wavelength of an electron.

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30. Calculate the momentum and de-Broglie wavelength of the electrons accelerated through a potential difference of 56V.

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31. Find the de Brogile wavelength associated with an electron accelerated under a potential difference of 100 V.

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32. Calculate the momentum and de-Broglie wavelength of the electrons accelerated through a potential difference of 56V.

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33. What voltage must be applied to an elecron microscope to produce electrons of wavelength $0.4\mathring{A}$?

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34. A photon and an electron have got same de Brogile wavelength. Which has greater total energy? Explain.

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35. A particle is moving with a speed three times as that of an electron.If the ratio of de-Broglie wavelength of the wave associated with the particle to that with the electron is

1.813×10^{-4} ,find the mass of hte particle.Can you identiify hte particle?Give that mass of the electron = $9.1 \times 01^{-31} kg$.

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36. The electron in given Bohr orbit has a total energy of -3.4 eV.Calculate its kinetic energy

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37. Calculate the de-Broglie waveelngth of an electron of energy 400 eV.Given,lanck's constant = $6.6 \times 10^{-34} Js$, mass of electron $= 9.1 \times 10^{31} kg, 1eV = 1.6 \times 10^{-19} J.$

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38. Compute the typical de-Broglie wavelength of an electron in a metal at $27^{\circ} C$ and compare it with the mean separation between two electrons in a metal which is given to be about $2 \times 10^{-10} m$.

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39. Find the typical de-Broglie wavelength associated with a He atom in helium gas at room temperatuare $(27^\circ C)$ and 1 atm pressure and compare it with the mean separation between two atoms under these conditions.

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40. What voltage must be applied to an elecron microscope to produce electrons of wavelength $0.4\overset{\circ}{A}$?

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