

Chapter 19. Dual Nature of Radiation and Matter

1. The de-Broglie wavelength of a neutron in thermal equilibrium with heavy water at a temperature T (kelvin) and mass m , is

(a) $\frac{h}{\sqrt{3mkT}}$	(b) $\frac{2h}{\sqrt{3mkT}}$
(c) $\frac{2h}{\sqrt{mkT}}$	(d) $\frac{h}{\sqrt{mkT}}$

(NEET 2017)
2. The photoelectric threshold wavelength of silver is 3250×10^{-10} m. The velocity of the electron ejected from a silver surface by ultraviolet light of wavelength 2536×10^{-10} m is
 [Given $h = 4.14 \times 10^{-15}$ eV s and $c = 3 \times 10^8$ m s $^{-1}$]
 (a) $\approx 0.6 \times 10^6$ m s $^{-1}$ (b) $\approx 61 \times 10^3$ m s $^{-1}$
 (c) $\approx 0.3 \times 10^6$ m s $^{-1}$ (d) $\approx 6 \times 10^5$ m s $^{-1}$

(NEET 2017)
3. Electrons of mass m with de-Broglie wavelength λ fall on the target in an X-ray tube. The cutoff wavelength (λ_0) of the emitted X-ray is

(a) $\lambda_0 = \frac{2mc\lambda^2}{h}$	(b) $\lambda_0 = \frac{2h}{mc}$
(c) $\lambda_0 = \frac{2m^2c^2\lambda^3}{h^2}$	(d) $\lambda_0 = \lambda$

(NEET-II 2016)
4. Photons with energy 5 eV are incident on a cathode C in a photoelectric cell. The maximum energy of emitted photoelectrons is 2 eV. When photons of energy 6 eV are incident on C, no photoelectrons will reach the anode A, if the stopping potential of A relative to C is

(a) +3 V	(b) +4 V
(c) -1 V	(d) -3 V

(NEET-II 2016)
5. An electron of mass m and a photon have same energy E . The ratio of de-Broglie wavelengths associated with them is

(a) $c(2mE)^{\frac{1}{2}}$	(b) $\frac{1}{c} \left(\frac{2m}{E} \right)^{\frac{1}{2}}$
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6. When a metallic surface is illuminated with radiation of wavelength λ , the stopping potential is V . If the same surface is illuminated with radiation of wavelength 2λ , the stopping potential is $\frac{V}{4}$. The threshold wavelength for the metallic surface is

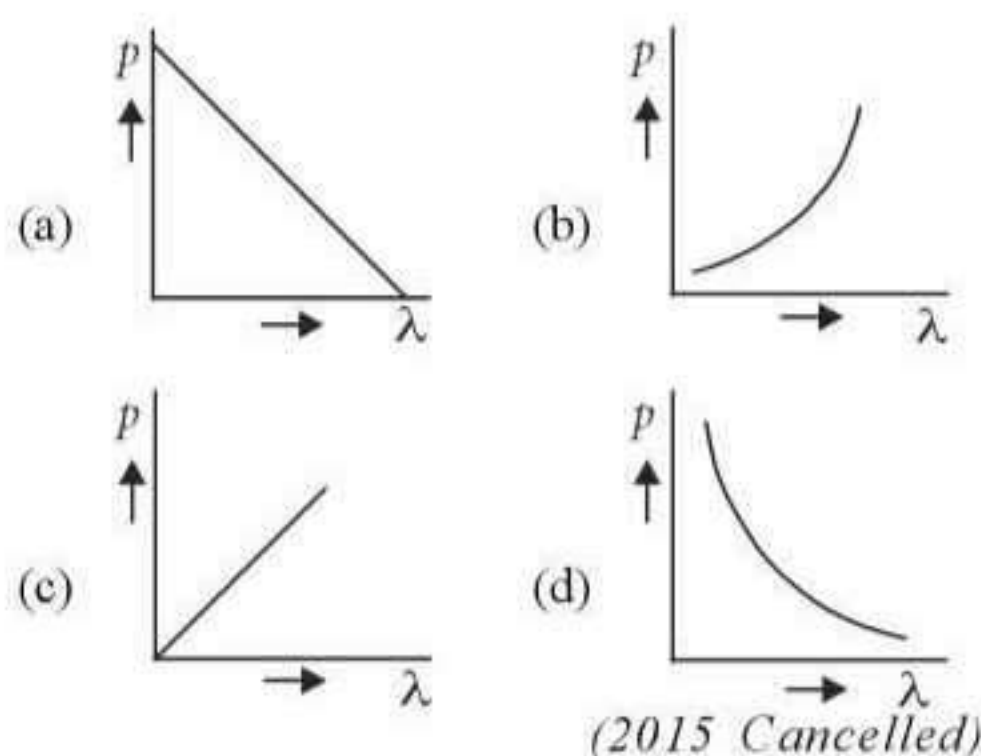
(a) $\frac{5}{2}\lambda$	(b) 3λ
(c) 4λ	(d) 5λ

(NEET-I 2016)
7. A photoelectric surface is illuminated successively by monochromatic light of wavelength λ and If the maximum kinetic energy of the emitted photoelectrons in the second case is 3 times that in the first case, the work function of the surface of the material is
 (h = Planck's constant, c = speed of light)

(a) $\frac{2hc}{\lambda}$	(b) $\frac{hc}{3\lambda}$
(c) $\frac{hc}{2\lambda}$	(d) $\frac{hc}{\lambda}$ <i>(2015)</i>
8. Light of wavelength 500 nm is incident on a metal with work function 2.28 eV. The de Broglie wavelength of the emitted electron is

(a) $\geq 2.8 \times 10^{-9}$ m	(b) $\leq 2.8 \times 10^{-12}$ m
(c) $< 2.8 \times 10^{-10}$ m	(d) $< 2.8 \times 10^{-9}$ m

(2015)
9. Which of the following figures represent the variation of particle momentum and the associated de-Broglie wavelength?



10. A certain metallic surface is illuminated with monochromatic light of wavelength, λ . The stopping potential for photo-electric current for this light is $3V_0$. If the same surface is illuminated with light of wavelength 2λ , the stopping potential is V_0 . The threshold wavelength for this surface for photo-electric effect is

(a) $\frac{\pi}{4}$ (b) $\frac{\lambda}{6}$ (c) 6λ (d) 4λ

(2015 Cancelled)

11. When the energy of the incident radiation is increased by 20%, the kinetic energy of the photoelectrons emitted from a metal surface increased from 0.5 eV to 0.8 eV. The work function of the metal is

(a) 0.65 eV (b) 1.0 eV
(c) 1.3 eV (d) 1.5 eV (2014)

12. If the kinetic energy of the particle is increased to 16 times its previous value, the percentage change in the de Broglie wavelength of the particle is

(a) 25 (b) 75
(c) 60 (d) 50 (2014)

13. The wavelength λ_e of an electron and λ_p of a photon of same energy E are related by

(a) $\lambda_p \propto \sqrt{\lambda_e}$ (b) $\lambda_p \propto \frac{1}{\sqrt{\lambda_e}}$
(c) $\lambda_p \propto \lambda_e^2$ (d) $\lambda_p \propto \lambda_e$

(NEET 2013)

14. For photoelectric emission from certain metal the cutoff frequency is ν . If radiation of frequency 2ν impinges on the metal plate, the maximum possible velocity of the emitted electron will be (m is the electron mass)

(a) $\sqrt{\frac{2h\nu}{m}}$ (b) $2\sqrt{\frac{h\nu}{m}}$
(c) $\sqrt{\frac{h\nu}{2m}}$ (d) $\sqrt{\frac{h\nu}{m}}$

(NEET 2013)

15. A source of light is placed at a distance of 50 cm from a photo cell and the stopping potential is found to be V_0 . If the distance between the light source and photo cell is made 25 cm, the new stopping potential will be

(a) $V_0/2$ (b) V_0 (c) $4V_0$ (d) $2V_0$

(Karnataka NEET 2013)

16. The de-Broglie wavelength of neutrons in thermal equilibrium at temperature T is

(a) $\frac{3.08}{\sqrt{T}} \text{ \AA}$ (b) $\frac{0.308}{\sqrt{T}} \text{ \AA}$
(c) $\frac{0.0308}{\sqrt{T}} \text{ \AA}$ (d) $\frac{30.8}{\sqrt{T}} \text{ \AA}$

(Karnataka NEET 2013)

17. A 200 W sodium street lamp emits yellow light of wavelength $0.6 \mu\text{m}$. Assuming it to be 25% efficient in converting electrical energy to light, the number of photons of yellow light it emits per second is

(a) 1.5×10^{20} (b) 6×10^{18}
(c) 62×10^{20} (d) 3×10^{19} (2012)

18. Monochromatic radiation emitted when electron on hydrogen atom jumps from first excited to the ground state irradiates a photosensitive material. The stopping potential is measured to be 3.57 V. The threshold frequency of the material is

(a) $4 \times 10^{15} \text{ Hz}$ (b) $5 \times 10^{15} \text{ Hz}$
(c) $1.6 \times 10^{15} \text{ Hz}$ (d) $2.5 \times 10^{15} \text{ Hz}$

(2012)

19. An α -particle moves in a circular path of radius 0.83 cm in the presence of a magnetic field of 0.25 Wb/m^2 . The de Broglie wavelength associated with the particle will be

(a) 1 \AA (b) 0.1 \AA
(c) 10 \AA (d) 0.01 \AA (2012)

20. If the momentum of an electron is changed by P , then the de Broglie wavelength associated with it changes by 0.5%. The initial momentum of electron will be

- (a) $200P$ (b) $400P$ (c) $\frac{P}{200}$ (d) $100P$
(Mains 2012)
21. Two radiations of photons energies 1 eV and 2.5 eV, successively illuminate a photosensitive metallic surface of work function 0.5 eV. The ratio of the maximum speeds of the emitted electrons is
(a) 1:4 (b) 1:2 (c) 1:1 (d) 1:5
(Mains 2012)
22. Photoelectric emission occurs only when the incident light has more than a certain minimum
(a) power (b) wavelength
(c) intensity (d) frequency
(2011)
23. In the Davisson and Germer experiment, the velocity of electrons emitted from the electron gun can be increased by
(a) increasing the potential difference between the anode and filament
(b) increasing the filament current
(c) decreasing the filament current
(d) decreasing the potential difference between the anode and filament (2011)
24. Light of two different frequencies whose photons have energies 1 eV and 2.5 eV respectively illuminate a metallic surface whose work function is 0.5 eV successively. Ratio of maximum speeds of emitted electrons will be
(a) 1:4 (b) 1:2 (c) 1:1 (d) 1:5
(2011)
25. Electrons used in an electron microscope are accelerated by a voltage of 25 kV. If the voltage is increased to 100 kV then the de-Broglie wavelength associated with the electrons would
(a) increase by 2 times
(b) decrease by 2 times
(c) decrease by 4 times
(d) increase by 4 times (2011)
26. In photoelectric emission process from a metal of work function 1.8 eV, the kinetic energy of most energetic electrons is 0.5 eV. The corresponding stopping potential is
(a) 1.8 V (b) 1.3 V
(c) 0.5 V (d) 2.3 V (2011)
27. The threshold frequency for a photosensitive metal is 3.3×10^{14} Hz. If light of frequency 8.2×10^{14} Hz is incident on this metal, the cut-off voltage for the photoelectron emission is nearly
(a) 1 V (b) 2 V (c) 3 V (d) 5 V
(Mains 2011)
28. A beam of cathode rays is subjected to crossed electric (E) and magnetic fields (B). The fields are adjusted such that the beam is not deflected. The specific charge of the cathode rays is given by
(a) $\frac{B^2}{2VE^2}$ (b) $\frac{2VB^2}{E^2}$
(c) $\frac{2VE^2}{B^2}$ (d) $\frac{E^2}{2VB^2}$ (2010)
(Where V is the potential difference between cathode and anode)
29. A source S_1 is producing, 10^{15} photons per second of wavelength 5000 Å. Another source S_2 is producing 1.02×10^{15} photons per second of wavelength 5100 Å. Then, (power of S_2)/(power of S_1) is equal to
(a) 1.00 (b) 1.02
(c) 1.04 (d) 0.98 (2010)
30. The potential difference that must be applied to stop the fastest photoelectrons emitted by a nickel surface, having work function 5.01 eV, when ultraviolet light of 200 nm falls on it, must be
(a) 2.4 V (b) -1.2 V
(c) -2.4 V (d) 1.2 V (2010)
31. When monochromatic radiation of intensity I falls on a metal surface, the number of photoelectrons and their maximum kinetic energy are N and T respectively. If the intensity of radiation is $2I$, the number of emitted electrons and their maximum kinetic energy are respectively
(a) N and $2T$ (b) $2N$ and T
(c) $2N$ and $2T$ (d) N and T
(Mains 2010)
32. The electron in the hydrogen atom jumps from excited state ($n = 3$) to its ground state ($n = 1$) and the photons thus emitted irradiate a photosensitive material. If the work function

of the material is 5.1 eV, the stopping potential is estimated to be (the energy of the electron

$$\text{in } n^{\text{th}} \text{ state } E_n = \frac{-13.6}{n^2} \text{ eV}$$

- (a) 5.1 V (b) 12.1 V (c) 17.2 V (d) 7 V

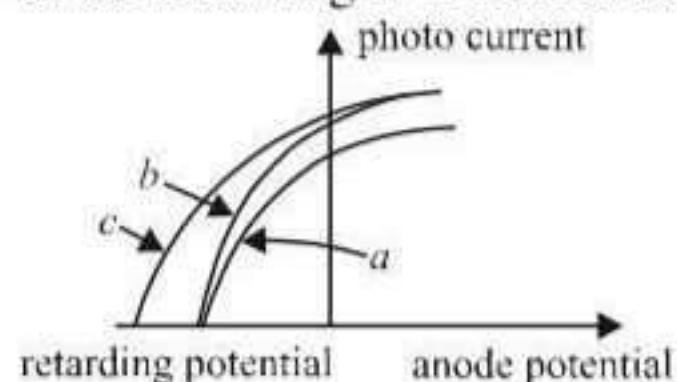
(Mains 2010)

33. The number of photo electrons emitted for light of a frequency ν (higher than the threshold frequency ν_0) is proportional to

- (a) threshold frequency (ν_0)
 (b) intensity of light
 (c) frequency of light (ν)
 (d) $\nu - \nu_0$

(2009)

34. The figure shows a plot of photo current versus anode potential for a photo sensitive surface for three different radiations. Which one of the following is a correct statement?



- (a) Curves (a) and (b) represent incident radiations of same frequency but of different intensities.
 (b) Curves (b) and (c) represent incident radiations of different frequencies and different intensities.
 (c) Curves (b) and (c) represent incident radiations of same frequency having same intensity.
 (d) Curves (a) and (b) represent incident radiations of different frequencies and different intensities

(2009)

35. Monochromatic light of wavelength 667 nm is produced by a helium neon laser. The power emitted is 9 mW. The number of photons arriving per sec. on the average at a target irradiated by this beam is

- (a) 3×10^{16} (b) 9×10^{15}
 (c) 3×10^{19} (d) 9×10^{17}

(2009)

36. The work function of a surface of a photosensitive material is 6.2 eV. The wavelength of the incident radiation for which the stopping potential is 5 V lies in the

- (a) Infrared region (b) X-ray region
 (c) Ultraviolet region (d) Visible region

(2008)

37. A particle of mass 1 mg has the same wavelength as an electron moving with a velocity of $3 \times 10^6 \text{ m s}^{-1}$. The velocity of the particle is

- (a) $3 \times 10^{-31} \text{ ms}^{-1}$ (b) $2.7 \times 10^{-21} \text{ ms}^{-1}$
 (c) $2.7 \times 10^{-18} \text{ ms}^{-1}$ (d) $9 \times 10^{-2} \text{ ms}^{-1}$

(mass of electron = $9.1 \times 10^{-31} \text{ kg}$) (2008)

38. In the phenomenon of electric discharge through gases at low pressure, the coloured glow in the tube appears as a result of

- (a) collisions between the charged particles emitted from the cathode and the atoms of the gas
 (b) collision between different electrons of the atoms of the gas
 (c) excitation of electrons in the atoms
 (d) collision between the atoms of the gas

(2008)

39. A beam of electron passes undeflected through mutually perpendicular electric and magnetic fields. If the electric field is switched off and the same magnetic field is maintained, the electrons move

- (a) in a circular orbit
 (b) along a parabolic path
 (c) along a straight line
 (d) in an elliptical orbit

(2007)

40. Monochromatic light of frequency $6.0 \times 10^{14} \text{ Hz}$ is produced by a laser. The power emitted is $2 \times 10^{-3} \text{ W}$. The number of photons emitted, on the average, by the source per second is

- (a) 5×10^{16} (b) 5×10^{17}
 (c) 5×10^{14} (d) 5×10^{15}

(2007)

41. A 5 watt source emits monochromatic light of wavelength 5000 Å. When placed 0.5 m away, it liberates photoelectrons from a photosensitive metallic surface. When the source is moved to a distance of 1.0 m, the number of photoelectrons liberated will be reduced by a factor of

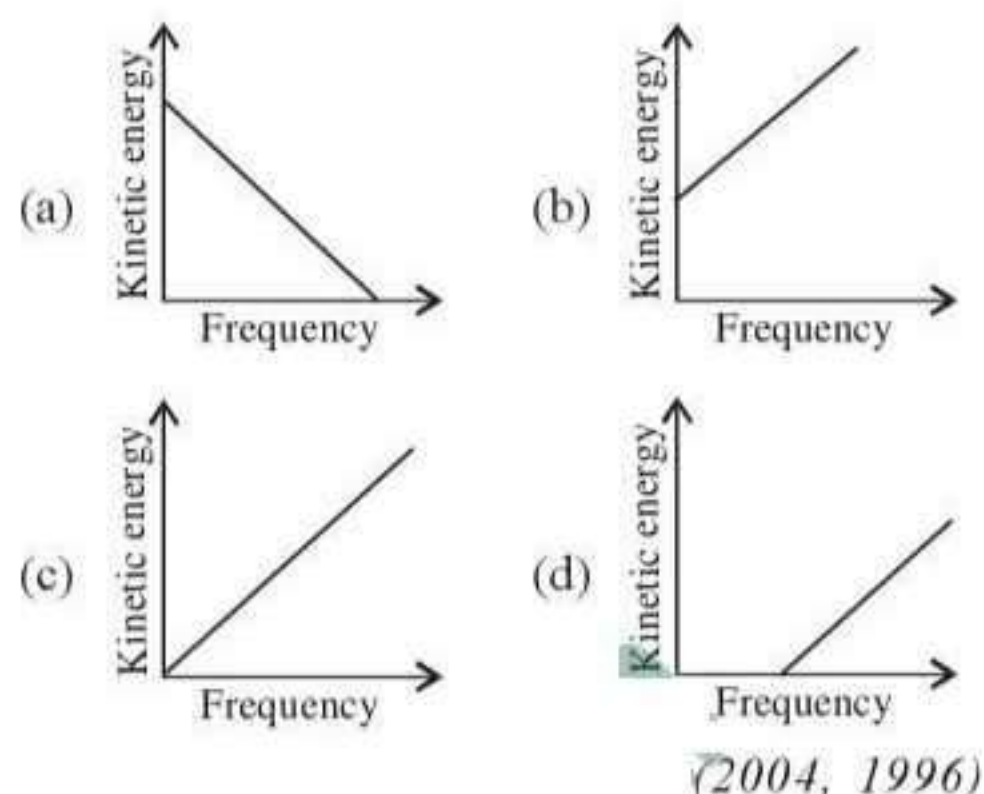
- (a) 8 (b) 16
 (c) 2 (d) 4

(2007)

42. A photocell employs photoelectric effect to convert

- (a) change in the frequency of light into a change in the electric current
 (b) change in the frequency of light into a change in electric voltage

- (c) change in the intensity of illumination into a change in photoelectric current
 (d) change in the intensity of illumination into a change in the work function of the photocathode. (2006)
43. When photons of energy $h\nu$ fall on an aluminium plate (of work function E_0), photoelectrons of maximum kinetic energy K are ejected. If the frequency of radiation is doubled, the maximum kinetic energy of the ejected photoelectrons will be
 (a) $K + h\nu$ (b) $K + E_0$
 (c) $2K$ (d) K . (2006)
44. In a discharge tube ionization of enclosed gas is produced due to collisions between
 (a) neutral gas atoms/molecules
 (b) positive ions and neutral atoms/molecules
 (c) negative electrons and neutral atoms/molecules
 (d) photons and neutral atoms/molecules. (2006)
45. The momentum of a photon of energy 1 MeV in kg m/s will be
 (a) 5×10^{-22} (b) 0.33×10^6
 (c) 7×10^{-24} (d) 10^{-22} . (2006)
46. The work functions for metals A, B and C are respectively 1.92 eV, 2.0 eV and 5 eV. According to Einstein's equation the metals which will emit photoelectrons for a radiation of wavelength 4100 Å is/are
 (a) A only
 (b) A and B only
 (c) all the three metals
 (d) none. (2005)
47. A photosensitive metallic surface has work function, $h\nu_0$. If photons of energy $2h\nu_0$ fall on this surface, the electrons come out with a maximum velocity of 4×10^6 m/s. When the photon energy is increased to $5h\nu_0$, then maximum velocity of photoelectrons will be
 (a) 2×10^7 m/s (b) 2×10^6 m/s
 (c) 8×10^6 m/s (d) 8×10^5 m/s. (2005)
48. According to Einstein's photoelectric equation, the graph between the kinetic energy of photoelectrons ejected and the frequency of incident radiation is



49. A photoelectric cell is illuminated by a point source of light 1 m away. When the source is shifted to 2 m then
 (a) each emitted electron carries one quarter of the initial energy
 (b) number of electrons emitted is half the initial number
 (c) each emitted electron carries half the initial energy
 (d) number of electrons emitted is a quarter of the initial number (2003)
50. J.J. Thomson's cathode-ray tube experiment demonstrated that
 (a) cathode rays are streams of negatively charged ions
 (b) all the mass of an atom is essentially in the nucleus
 (c) the e/m of electrons is much greater than the e/m of protons
 (d) the e/m ratio of the cathode-ray particles changes when a different gas is placed in the discharge tube (2003)
51. The value of Planck's constant is
 (a) 6.63×10^{-34} J/sec.
 (b) 6.63×10^{-34} kg-m²/sec
 (c) 6.63×10^{-34} kg-m²
 (d) 6.63×10^{-34} J-sec. (2002)
52. If particles are moving with same velocity, then which has maximum de Broglie wavelength?
 (a) proton (b) α -particle
 (c) neutron (d) β -particle. (2002)
53. When ultraviolet rays incident on metal plate then photoelectric effect does not occur, it occurs by incidence of
 (a) infrared rays (b) X-rays
 (c) radio wave (d) micro wave. (2002)

54. Which of the following is not the property of cathode rays?
 (a) It produces heating effect
 (b) It does not deflect in electric field
 (c) It casts shadow
 (d) It produces fluorescence. (2002)
55. Which one among the following shows particle nature of light?
 (a) photo electric effect (b) interference
 (b) refraction (d) polarization. (2001)
56. In Thomson mass spectrograph $\vec{E} \perp \vec{B}$ then the velocity of electron beam will be
 (a) $\frac{|\vec{E}|}{|\vec{B}|}$ (b) $\vec{E} \times \vec{B}$
 (c) $\frac{|\vec{B}|}{|\vec{E}|}$ (d) $\frac{\vec{E}^2}{\vec{B}^2}$. (2001)
57. A photo-cell is illuminated by a source of light, which is placed at a distance d from the cell. If the distance become $d/2$, then number of electrons emitted per second will be
 (a) remain same (b) four times
 (c) two times (d) one-fourth. (2001)
58. By photoelectric effect, Einstein proved
 (a) $E = h\nu$ (b) $\text{K.E.} = \frac{1}{2}mv^2$
 (c) $E = mc^2$ (d) $E = \frac{Rhc^2}{n^2}$. (2000)
59. Who evaluated the mass of electron indirectly with help of charge
 (a) Thomson (b) Millikan
 (c) Rutherford (d) Newton. (2000)
60. When a proton is accelerated through 1 V, then its kinetic energy will be
 (a) 1 eV (b) 13.6 eV
 (c) 1840 eV (d) 0.54 eV (1999)
61. The photoelectric work function for a metal surface is 4.125 eV. The cut-off wavelength for this surface is
 (a) 3000 Å (b) 2062.5 Å
 (c) 4125 Å (d) 6000 Å (1999)
62. As the intensity of incident light increases
 (a) kinetic energy of emitted photoelectrons increases
 (b) photoelectric current decreases
 (c) photoelectric current increases
 (d) kinetic energy of emitted photoelectrons decreases (1999)
63. In a photo-emissive cell, with exciting wavelength λ , the fastest electron has speed v . If the exciting wavelength is changed to $\frac{3\lambda}{4}$, the speed of the fastest emitted electron will be
 (a) less than $v(4/3)^{1/2}$
 (b) $v(4/3)^{1/2}$
 (c) $v(3/4)^{1/2}$
 (d) greater than $v(4/3)^{1/2}$ (1998)
64. Which of the following statement is correct?
 (a) The photocurrent increases with intensity of light
 (b) The stopping potential increases with increase of incident light
 (c) The current in photocell increases with increasing frequency
 (d) The photocurrent is proportional to the applied voltage. (1997)
65. The kinetic energy of an electron, which is accelerated in the potential difference of 100 volts, is
 (a) 416.6 cal (b) 6.636 cal
 (c) 1.602×10^{-17} J (d) 1.6×10^4 J. (1997)
66. An electron beam has a kinetic energy equal to 100 eV. Find its wavelength associated with a beam, if mass of electron = 9.1×10^{-31} kg and $1 \text{ eV} = 1.6 \times 10^{-19} \text{ J/eV}$. (Planck's constant = 6.6×10^{-34} Js)
 (a) 24.6 Å (b) 0.12 Å
 (c) 1.2 Å (d) 6.3 Å. (1996)
67. In a discharge tube at 0.02 mm, there is formation of
 (a) Crooke's dark space
 (b) Faraday's dark space
 (c) both space partly
 (d) none of these. (1996)
68. An electron of mass m and charge e is accelerated from rest through a potential difference V in vacuum. Its final velocity will be

- (a) $\sqrt{\frac{2eV}{m}}$ (b) $\sqrt{\frac{eV}{m}}$
 (c) $\frac{eV}{2m}$ (d) $\frac{eV}{m}$ (1996)
69. If a photon has velocity c and frequency ν , then which of the following represents its wavelength?
 (a) $\frac{h\nu}{c^2}$ (b) $h\nu$ (c) $\frac{hc}{E}$ (d) $\frac{h\nu}{c}$ (1996)
70. The velocity of photons is proportional to (where ν = frequency)
 (a) $1/\sqrt{\nu}$ (b) ν^2
 (c) ν (d) $\sqrt{\nu}$ (1996)
71. An electron of mass m , when accelerated through a potential difference V , has de Broglie wavelength λ . The de Broglie wavelength associated with a proton of mass M accelerated through the same potential difference, will be
 (a) $\lambda \frac{M}{m}$ (b) $\lambda \frac{m}{M}$
 (c) $\lambda \sqrt{\frac{M}{m}}$ (d) $\lambda \sqrt{\frac{m}{M}}$ (1995)
72. If we consider electrons and photons of same wavelength, then they will have same
 (a) momentum
 (b) angular momentum
 (c) energy
 (d) velocity (1995)
73. When light of wavelength 300 nm (nanometer) falls on a photoelectric emitter, photoelectrons are liberated. For another emitter, however, light of 600 nm wavelength is sufficient for creating photoemission. What is the ratio of the work functions of the two emitters?
 (a) 1 : 2 (b) 2 : 1
 (c) 4 : 1 (d) 1 : 4 (1993)
74. Number of ejected photoelectrons increases with increase
 (a) in intensity of light
 (b) in wavelegh of light
 (c) in frequency of light
 (d) never (1993)
75. Momentum of photon wavelength λ is
 (a) $\frac{h\nu}{c}$ (b) zero (c) $\frac{h\lambda}{c^2}$ (d) $\frac{h\lambda}{c}$ (1993)
76. The cathode of a photoelectric cell is changed such that the work function changes from W_1 to W_2 ($W_2 > W_1$). If the current before and after changes are I_1 and I_2 , all other conditions remaining unchanged, then (assuming $h\nu > W_2$)
 (a) $I_1 = I_2$ (b) $I_1 < I_2$
 (c) $I_1 > I_2$ (d) $I_1 > I_2 < 2I_1$ (1992)
77. Photoelectric work function of a metal is 1 eV. Light of wavelength $\lambda = 3000 \text{ \AA}$ falls on it. The photo electrons come out with a maximum velocity
 (a) 10 metres/sec (b) 10^2 metres/ sec
 (c) 10^4 metres/sec (d) 10^6 metres/sec (1991)
78. The wavelength of a 1 keV photon is $1.24 \times 10^{-9} \text{ m}$. What is the frequency of 1 MeV photon?
 (a) 1.24×10^{15} (b) 2.4×10^{20}
 (c) 1.24×10^{18} (d) 2.4×10^{23} (1991)
79. An electron with (rest mass m_0) moves with a speed of $0.8c$. Its mass when it moves with this speed is
 (a) m_0 (b) $\frac{m_0}{6}$
 (c) $\frac{5m_0}{3}$ (d) $\frac{3m_0}{5}$ (1991)
80. A radio transmitter operates at a frequency 880 kHz and a power of 10 kW. The number of photons emitted per second is
 (a) 1.72×10^{31} (b) 1.327×10^{25}
 (c) 1.327×10^{37} (d) 1.327×10^{45} (1990)
81. The momentum of a photon of an electromagnetic radiation is $3.3 \times 10^{-29} \text{ kg ms}^{-1}$. What is the frequency of the associated waves?
 [$h = 6.6 \times 10^{-34} \text{ Js}$; $c = 3 \times 10^8 \text{ ms}^{-1}$]
 (a) $1.5 \times 10^{13} \text{ Hz}$ (b) $7.5 \times 10^{12} \text{ Hz}$
 (c) $6 \times 10^3 \text{ Hz}$ (d) $3 \times 10^3 \text{ Hz}$ (1990)



- 82.** Ultraviolet radiations of 6.2 eV falls on an aluminium surface. Kinetic energy of fastest electron emitted is (work function = 4.2 eV)
 (a) 3.2×10^{-21} J (b) 3.2×10^{-19} J
 (c) 7×10^{-25} J (d) 9×10^{-32} J
 (1989)
- 83.** The de Broglie wave corresponding to a particle of mass m and velocity v has a wavelength associated with it
 (a) $\frac{h}{mv}$ (b) hmv
 (c) $\frac{mh}{v}$ (d) $\frac{m}{hv}$ (1989)
- 84.** The energy of a photon of wavelength λ is
 (a) $hc\lambda$ (b) $\frac{hc}{\lambda}$
 (c) $\frac{\lambda}{hc}$ (d) $\frac{\lambda h}{c}$ (1988)
- 85.** Thermions are
 (a) protons (b) electrons
 (c) photons (d) positrons (1988)
- 86.** The threshold frequency for photoelectric effect on sodium corresponds to a wavelength of 5000 Å. Its work function is
 (a) 4×10^{-19} J (b) 1 J
 (c) 2×10^{-19} J (d) 3×10^{-19} J
 (1988)

Answer Key

1. (a) 2. (a, d) 3. (a) 4. (d) 5. (c) 6. (b) 7. (c) 8. (a) 9. (d) 10. (d)
 11. (b) 12. (b) 13. (c) 14. (a) 15. (b) 16. (d) 17. (a) 18. (c) 19. (d) 20. (a)
 21. (b) 22. (d) 23. (a) 24. (b) 25. (b) 26. (c) 27. (b) 28. (d) 29. (a) 30. (b)
 31. (b) 32. (d) 33. (b) 34. (a) 35. (a) 36. (c) 37. (c) 38. (a) 39. (a) 40. (d)
 41. (d) 42. (c) 43. (a) 44. (c) 45. (a) 46. (b) 47. (c) 48. (d) 49. (d) 50. (c)
 51. (d) 52. (d) 53. (b) 54. (b) 55. (a) 56. (a) 57. (b) 58. (a) 59. (a) 60. (a)
 61. (a) 62. (c) 63. (d) 64. (a) 65. (c) 66. (c) 67. (a) 68. (a) 69. (c) 70. (*)
 71. (d) 72. (a) 73. (b) 74. (a) 75. (a) 76. (a) 77. (d) 78. (b) 79. (c) 80. (a)
 81. (a) 82. (b) 83. (a) 84. (b) 85. (b) 86. (a)

* None is correct.



EXPLANATIONS

1. (a) : Kinetic energy of a neutron in thermal equilibrium with heavy water at a temperature T is given as

$$K = \frac{3}{2}kT \quad \dots(i)$$

Also momentum (p) is, $p = \sqrt{2mK}$

From eqn. (i)

$$p = \sqrt{2m \cdot \frac{3}{2}kT} = \sqrt{3mkT}$$

Required de-Broglie wavelength is given as

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{3mkT}}$$

2. (a, d) : The maximum kinetic energy is given as

$$K_{\max} = h\nu - \phi_0 = h\nu - h\nu_0 = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$$

where λ_0 = threshold wavelength

$$\text{or } \frac{1}{2}mv^2 = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$$

Here, $h = 4.14 \times 10^{-15} \text{ eV s}$, $c = 3 \times 10^8 \text{ m s}^{-1}$

$$\lambda_0 = 3250 \times 10^{-10} \text{ m} = 3250 \text{ \AA}$$

$$\lambda = 2536 \times 10^{-10} \text{ m} = 2536 \text{ \AA},$$

$$m = 9.1 \times 10^{-31} \text{ kg}$$

$$hc = 4.14 \times 10^{-15} \text{ eV s} \times 3 \times 10^8 \text{ m s}^{-1} \\ = 12420 \text{ eV \AA}$$

$$\therefore \frac{1}{2}mv^2 = 12420 \left[\frac{1}{2536} - \frac{1}{3250} \right] \text{ eV} \\ = 1.076 \text{ eV}$$

$$v^2 = \frac{2.152 \text{ eV}}{m} = \frac{2.152 \times 1.6 \times 10^{-19}}{9.1 \times 10^{-31}}$$

$$\therefore v \approx 6 \times 10^5 \text{ m s}^{-1} = 0.6 \times 10^6 \text{ m s}^{-1}$$

Note: Options (a) and (d) are same. So both are correct.

3. (a) : Kinetic energy of electrons

$$K = \frac{p^2}{2m} = \frac{(h/\lambda)^2}{2m} = \frac{h^2}{2m\lambda^2}$$

So, maximum energy of photon = K

$$\frac{hc}{\lambda_0} = \frac{h^2}{2m\lambda^2} \quad \therefore \lambda_0 = \frac{2mc\lambda^2}{h}$$

4. (d) : According Einstein's photoelectric equation maximum kinetic energy of photoelectrons,

$$KE_{\max} = E_v - \phi$$

or $2 = 5 - \phi \quad \therefore \phi = 3 \text{ eV}$

When $E_v = 6 \text{ eV}$ then

$$KE_{\max} = 6 - 3 = 3 \text{ eV}$$

or $e(V_{\text{cathode}} - V_{\text{anode}}) = 3 \text{ eV}$

or $V_{\text{cathode}} - V_{\text{anode}} = 3 \text{ V} = -V_{\text{stopping}}$

$$\therefore V_{\text{stopping}} = -3 \text{ V}$$

5. (c) : For electron of energy E ,

$$\text{de-Broglie wavelength, } \lambda_e = \frac{h}{p} = \frac{h}{\sqrt{2mE}}$$

For photon of energy, $E = h\nu = \frac{hc}{\lambda_p}$

$$\Rightarrow \lambda_p = \frac{hc}{E}$$

$$\therefore \frac{\lambda_e}{\lambda_p} = \frac{h}{\sqrt{2mE}} \times \frac{E}{hc} = \frac{1}{c} \left(\frac{E}{2m} \right)^{1/2}$$

6. (b) : According to Einstein's photoelectric equation,

$$eV_s = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$$

$$\therefore \text{As per question, } eV = \frac{hc}{\lambda} - \frac{hc}{\lambda_0} \quad \dots(i)$$

$$\frac{eV}{4} = \frac{hc}{2\lambda} - \frac{hc}{\lambda_0} \quad \dots(ii)$$

From equations (i) and (ii), we get

$$\frac{hc}{2\lambda} - \frac{hc}{4\lambda} = \frac{hc}{\lambda_0} - \frac{hc}{4\lambda_0}$$

$$\Rightarrow \frac{hc}{4\lambda} = \frac{3hc}{4\lambda_0} \quad \text{or } \lambda_0 = 3\lambda$$

7. (c) : Let ϕ_0 be the work function of the surface of the material. Then,

According to Einstein's photoelectric equation, the maximum kinetic energy of the emitted photoelectrons in the first case is

$$K_{\max_1} = \frac{hc}{\lambda} - \phi_0$$

and that in the second case is

$$K_{\max_2} = \frac{hc}{\lambda} - \phi_0 = \frac{2hc}{\lambda} - \phi_0$$

But $K_{\max_2} = 3K_{\max_1}$ (given)

$$\therefore \frac{2hc}{\lambda} - \phi_0 = 3 \left(\frac{hc}{\lambda} - \phi_0 \right)$$

$$\frac{2hc}{\lambda} - \phi_0 = \frac{3hc}{\lambda} - 3\phi_0$$

$$3\phi_0 - \phi_0 = \frac{3hc}{\lambda} - \frac{2hc}{\lambda}$$

$$2\phi_0 = \frac{hc}{\lambda} \quad \text{or} \quad \phi_0 = \frac{hc}{2\lambda}$$

8. (a) : According to Einstein's photoelectric equation, the maximum kinetic energy of the emitted electron is

$$K_{\max} = \frac{hc}{\lambda} - \phi_0$$

where λ is the wavelength of incident light and ϕ_0 is the work function.

Here, $\lambda = 500 \text{ nm}$, $hc = 1240 \text{ eV nm}$ and $\phi_0 = 2.28 \text{ eV}$

$$\begin{aligned} \therefore K_{\max} &= \frac{1240 \text{ eV nm}}{500 \text{ nm}} - 2.28 \text{ eV} \\ &= 2.48 \text{ eV} - 2.28 \text{ eV} = 0.2 \text{ eV} \end{aligned}$$

The de Broglie wavelength of the emitted electron is

$$\lambda_{\min} = \frac{h}{\sqrt{2mK_{\max}}}$$

where h is the Planck's constant and m is the mass of the electron.

As $h = 6.6 \times 10^{-34} \text{ J s}$, $m = 9 \times 10^{-31} \text{ kg}$
and $K_{\max} = 0.2 \text{ eV} = 0.2 \times 1.6 \times 10^{-19} \text{ J}$

$$\begin{aligned} \therefore \lambda_{\min} &= \frac{6.6 \times 10^{-34} \text{ J s}}{\sqrt{2(9 \times 10^{-31} \text{ kg})(0.2 \times 1.6 \times 10^{-19} \text{ J})}} \\ &= \frac{6.6}{2.4} \times 10^{-9} \text{ m} = 2.8 \times 10^{-9} \text{ m} \end{aligned}$$

So, $\lambda \geq 2.8 \times 10^{-9} \text{ m}$

9. (d) : de-Broglie wavelength, $\lambda = \frac{h}{p}$

or $\lambda \propto \frac{1}{p}$, $\lambda p = \text{constant}$

This represents a rectangular hyperbola.

10. (d)

11. (b) : According to Einstein's photoelectric equation,

The kinetic energy of emitted photoelectrons is

$$K = h\nu - \phi_0$$

where $h\nu$ is the energy of incident radiation and ϕ_0 is work function of the metal.

As per question,

$$0.5 \text{ eV} = h\nu - \phi_0 \quad \dots (i)$$

$$0.8 \text{ eV} = 1.2h\nu - \phi_0 \quad \dots (ii)$$

On solving eqns. (i) and (ii), we get

$$\phi_0 = 1.0 \text{ eV}$$

12. (b) : de Broglie wavelength,

$$\lambda = \frac{h}{\sqrt{2mK}} \quad \dots (i)$$

where m is the mass and K is the kinetic energy of the particle.

When kinetic energy of the particle is increased to 16 times, then its de Broglie wavelength becomes,

$$\lambda' = \frac{h}{\sqrt{2m(16K)}} = \frac{1}{4} \frac{h}{\sqrt{2mK}} = \frac{\lambda}{4} \quad (\text{Using (i)})$$

% change in the de Broglie wavelength

$$\begin{aligned} &= \frac{\lambda - \lambda'}{\lambda} \times 100 = \left(1 - \frac{\lambda'}{\lambda}\right) \times 100 \\ &= \left(1 - \frac{1}{4}\right) \times 100 = 75\% \end{aligned}$$

13. (c) : Wavelength of an electron of energy E is

$$\lambda_e = \frac{h}{\sqrt{2m_e E}} \quad \dots (i)$$

Wavelength of a photon of same energy E is

$$\lambda_p = \frac{hc}{E} \quad \text{or} \quad E = \frac{hc}{\lambda_p} \quad \dots (ii)$$

Squaring both sides of Eq. (i), we get

$$\lambda_e^2 = \frac{h^2}{2m_e E} \quad \text{or} \quad E = \frac{h^2}{2m_e \lambda_e^2} \quad \dots (iii)$$

Equating (ii) and (iii), we get

$$\begin{aligned} \frac{hc}{\lambda_p} &= \frac{h^2}{2m_e \lambda_e^2} \quad \text{or} \quad \lambda_p = \frac{2m_e c}{h} \lambda_e^2 \\ \lambda_p &\propto \lambda_e^2 \end{aligned}$$

14. (a) : Work function, $\phi = h\nu$

According to Einstein's photoelectric equation

$$\frac{1}{2} m v_{\max}^2 = h(2\nu) - h\nu$$

$$\frac{1}{2} m v_{\max}^2 = h\nu$$

$$v_{\max}^2 = \frac{2h\nu}{m} \Rightarrow v_{\max} = \sqrt{\frac{2h\nu}{m}}$$

15. (b) : By changing the position of source of light from photocell, there will be a change in the intensity of light falling on photocell.

As stopping potential is independent of the intensity of the incident light, hence stopping potential remains same *i.e.*, V_0 .

16. (d) : de Broglie wavelength of neutrons in thermal equilibrium at temperature T is

$$\lambda = \frac{h}{\sqrt{2mk_B T}}$$

where m is the mass of the neutron

Here, $m = 1.67 \times 10^{-27}$ kg

$$k_B = 1.38 \times 10^{-23} \text{ J K}^{-1}$$

$$h = 6.63 \times 10^{-34} \text{ J s}$$

$$\begin{aligned} \therefore \lambda &= \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 1.67 \times 10^{-27} \times 1.38 \times 10^{-23} \times T}} \\ &= \frac{3.08 \times 10^{-34} \times 10^{25}}{\sqrt{T}} \text{ m} \\ &= \frac{30.8 \times 10^{-10}}{\sqrt{T}} = \frac{30.8}{\sqrt{T}} \text{ \AA} \end{aligned}$$

17. (a) : Energy of a photon,

$$= \frac{(6.6 \times 10^{-34} \text{ J s})(3 \times 10^8 \text{ m s}^{-1})}{0.6 \times 10^{-6} \text{ m}} = 33 \times 10^{-20} \text{ J}$$

Number of photons emitted per second is

$$N = \frac{25}{E} P = \frac{25}{33 \times 10^{-20} \text{ J}} \times 200 \text{ W} = 1.5 \times 10^{20}$$

18. (c) : For hydrogen atom, $E_n = -\frac{13.6}{n^2} \text{ eV}$

For ground state, $n = 1$

$$\therefore E_1 = -\frac{13.6}{1^2} = -13.6 \text{ eV}$$

For first excited state, $n = 2$

$$\therefore E_2 = -\frac{13.6}{2^2} = -3.4 \text{ eV}$$

The energy of the emitted photon when an electron jumps from first excited state to ground state is

$$h\nu = E_2 - E_1 = -3.4 \text{ eV} - (-13.6 \text{ eV}) = 10.2 \text{ eV}$$

Maximum kinetic energy,

$$K_{\text{max}} = eV_s = e \times 3.57 \text{ V} = 3.57 \text{ eV}$$

According to Einstein's photoelectric equation

$$K_{\text{max}} = h\nu - \phi_0$$

where ϕ_0 is the work function and $h\nu$ is the incident energy

$$\phi_0 = h\nu - K_{\text{max}} = 10.2 \text{ eV} - 3.57 \text{ eV} = 6.63 \text{ eV}$$

$$\begin{aligned} \text{Threshold frequency, } \nu_0 &= \frac{\phi_0}{h} = \frac{6.63 \times 1.6 \times 10^{-19} \text{ J}}{6.63 \times 10^{-34} \text{ J s}} \\ &= 1.6 \times 10^{15} \text{ Hz} \end{aligned}$$

19. (d) : Radius of the circular path of a charged particle in a magnetic field is given by

$$R = \frac{mv}{Bq} \quad \text{or} \quad mv = RBq$$

Here, $R = 0.83 \text{ cm} = 0.83 \times 10^{-2} \text{ m}$

$$B = 0.25 \text{ Wb m}^{-2}$$

$$q = 2e = 2 \times 1.6 \times 10^{-19} \text{ C}$$

$$\therefore mv = (0.83 \times 10^{-2})(0.25)(2 \times 1.6 \times 10^{-19})$$

de Broglie wavelength,

$$\begin{aligned} \lambda &= \frac{h}{mv} = \frac{6.6 \times 10^{-34}}{0.83 \times 10^{-2} \times 0.25 \times 2 \times 1.6 \times 10^{-19}} \\ &= 0.01 \text{ \AA} \end{aligned}$$

20. (a) : de Broglie wavelength associated with an electron is

$$\lambda = \frac{h}{P} \quad \text{or} \quad P = \frac{h}{\lambda}$$

$$\begin{aligned} \therefore \frac{\Delta P}{P} &= -\frac{\Delta \lambda}{\lambda} \\ \frac{P}{P_{\text{initial}}} &= \frac{0.5}{100} \\ P_{\text{initial}} &= 200P \end{aligned}$$

21. (b) : According to Einstein's photoelectric equation

$$\frac{1}{2}mv_{\text{max}}^2 = h\nu - \phi_0$$

where $\frac{1}{2}mv_{\text{max}}^2$ is the maximum kinetic energy of the emitted electrons, $h\nu$ is the incident energy and ϕ_0 is the work function of the metal.

$$\therefore \frac{1}{2}mv_{\text{max}1}^2 = 1 \text{ eV} - 0.5 \text{ eV} = 0.5 \text{ eV} \quad \dots(i)$$

$$\text{and } \frac{1}{2}mv_{\text{max}2}^2 = 2.5 \text{ eV} - 0.5 \text{ eV} = 2 \text{ eV} \quad \dots(ii)$$

Divide (i) and (ii), we get

$$\begin{aligned} \frac{v_{\text{max}1}^2}{v_{\text{max}2}^2} &= \frac{0.5}{2} \\ \frac{v_{\text{max}1}}{v_{\text{max}2}} &= \sqrt{\frac{0.5}{2}} = \frac{1}{2} \end{aligned}$$

22. (d) : According to Einstein's photoelectric equation

$$K_{\text{max}} = h\nu - h\nu_0$$

Since K_{max} is +ve, the photoelectric emission occurs only if

$$h\nu > h\nu_0 \quad \text{or} \quad \nu > \nu_0$$

The photoelectric emission occurs only when the incident light has more than a certain minimum

frequency. This minimum frequency is called threshold frequency.

23. (a)

24. (b) : Here, work function, $\phi_0 = 0.5 \text{ eV}$

According to Einstein's photoelectric equation

Maximum kinetic energy of the emitted electrons

$$= \text{Incident photon energy} - \text{Work function}$$

$$\therefore K_{\max_1} = 1 \text{ eV} - 0.5 \text{ eV} = 0.5 \text{ eV} \quad \dots(i)$$

$$\text{and } K_{\max_2} = 2.5 \text{ eV} - 0.5 \text{ eV} = 2 \text{ eV} \quad \dots(ii)$$

Divide (i) by (ii), we get

$$\frac{K_{\max_1}}{K_{\max_2}} = \frac{0.5 \text{ eV}}{2 \text{ eV}} = \frac{1}{4}$$

$$\frac{\frac{1}{2}mv_{\max_1}^2}{\frac{1}{2}mv_{\max_2}^2} = \frac{1}{4} \quad \text{or} \quad \frac{v_{\max_1}}{v_{\max_2}} = \sqrt{\frac{1}{4}} = \frac{1}{2}$$

25. (b) : The de Broglie wavelength λ associated with the electrons is

$$\lambda = \frac{1.227}{\sqrt{V}} \text{ nm}$$

where V is the accelerating potential in volts.

$$\text{or } \lambda \propto \frac{1}{\sqrt{V}}$$

$$\therefore \frac{\lambda_1}{\lambda_2} = \sqrt{\frac{V_2}{V_1}} = \sqrt{\frac{100 \times 10^3}{25 \times 10^3}} = 2 \quad \text{or} \quad \lambda_2 = \frac{\lambda_1}{2}$$

26. (c) : The stopping potential V_s is related to the maximum kinetic energy of the emitted electrons K_{\max} through the relation

$$K_{\max} = eV_s$$

$$0.5 \text{ eV} = eV_s \quad \text{or} \quad V_s = 0.5 \text{ V}$$

27. (b) : According to Einstein's photoelectric equation

$$eV_0 = h\nu - h\nu_0$$

where, ν = Incident frequency

ν_0 = Threshold frequency

V_0 = Cut-off or stopping potential

$$\text{or } V_0 = \frac{h}{e}(\nu - \nu_0)$$

Substituting the given values, we get

$$V_0 = \frac{6.63 \times 10^{-34}(8.2 \times 10^{14} - 3.3 \times 10^{14})}{1.6 \times 10^{-19}} \approx 2 \text{ V}$$

28. (d) : When a beam of cathode rays (or electrons) are subjected to crossed electric (E) and magnetic (B) fields, the beam is not deflected, if
Force on electron due to = Force on electron due

magnetic field to electric field

$$Bev = eE$$

$$\text{or } v = \frac{E}{B} \quad \dots(i)$$

If V is the potential difference between the anode and the cathode, then

$$\therefore \frac{1}{2}mv^2 = eV$$

$$\frac{e}{m} = \frac{v^2}{2V} \quad \dots(ii)$$

Substituting the value of v from equation (i) in equation (ii), we get

$$\frac{e}{m} = \frac{E^2}{2VB^2}$$

Specific charge of the cathode rays $\frac{e}{m} = \frac{E^2}{2VB^2}$

29. (a) : For a source S_1 ,

Wavelength, $\lambda_1 = 5000 \text{ \AA}$

Number of photons emitted per second, $N_1 = 10^{15}$

Energy of each photon, $E_1 = \frac{hc}{\lambda_1}$

Power of source S_1 , $P_1 = E_1 N_1 = \frac{N_1 hc}{\lambda_1}$

For a source S_2 ,

Wavelength, $\lambda_2 = 5100 \text{ \AA}$

Number of photons emitted per second,

$$N_2 = 1.02 \times 10^{15}$$

Energy of each photon, $E_2 = \frac{hc}{\lambda_2}$

Power of source S_2 , $P_2 = N_2 E_2 = \frac{N_2 hc}{\lambda_2}$

$$\therefore \frac{\text{Power of } S_2}{\text{Power of } S_1} = \frac{P_2}{P_1} = \frac{\frac{N_2 hc}{\lambda_2}}{\frac{N_1 hc}{\lambda_1}} = \frac{N_2 \lambda_1}{N_1 \lambda_2}$$

$$= \frac{(1.02 \times 10^{15} \text{ photons/s}) \times (5000 \text{ \AA})}{(10^{15} \text{ photons/s}) \times (5100 \text{ \AA})} = \frac{51}{51} = 1$$

30. (b) : Here,

Incident wavelength, $\lambda = 200 \text{ nm}$

Work function, $\phi_0 = 5.01 \text{ eV}$

According to Einstein's photoelectric equation

$$eV_s = h\nu - \phi_0$$

$$eV_s = \frac{hc}{\lambda} - \phi_0$$

where V_s is the stopping potential

$$eV_s = \frac{(1240 \text{ eV nm})}{(200 \text{ nm})} - 5.01 \text{ eV}$$

$$= 6.2 \text{ eV} - 5.01 \text{ eV} = 1.2 \text{ eV}$$

Stopping potential, $V_s = 1.2 \text{ V}$

The potential difference that must be applied to stop photoelectrons $= -V_s = -1.2 \text{ V}$

31. (b) : The number of photoelectrons ejected is directly proportional to the intensity of incident light. Maximum kinetic energy is independent of intensity of incident light but depends upon the frequency of light. Hence option (b) is correct.

32. (d) : Energy released when electron in the atom jumps from excited state ($n = 3$) to ground state

($n = 1$) is

$$E = h\nu = E_3 - E_1 = \frac{-13.6}{3^2} - \left(\frac{-13.6}{1^2} \right)$$

$$= \frac{-13.6}{9} + 13.6 = 12.1 \text{ eV}$$

Therefore, stopping potential

$$eV_0 = h\nu - \phi_0$$

$$= 12.1 - 5.1 \quad [\because \text{work function } \phi_0 = 5.1]$$

$$V_0 = 7 \text{ V}$$

33. (b) : The number of photoelectrons decide the photocurrent. Assuming that the number of electrons emitted depends on the number of photons incident, the number of photoelectrons depend on the intensity of light.

34. (a)

35. (a) : $\lambda = 6670 \text{ \AA}$

$$E \text{ of a photon} = \frac{12400 \text{ eV \AA}}{6670 \text{ \AA}} = \frac{12400}{6670} \times 1.6 \times 10^{-19} \text{ J.}$$

Energy emitted per second, power $P = 9 \times 10^{-3} \text{ J}$

$$\therefore \text{Number of photons incident} = \frac{\text{Power}}{\text{Energy}} = \frac{P}{E}$$

$$= \frac{9 \times 10^{-3} \times 6670}{12400 \times 1.6 \times 10^{-19}} = 3 \times 10^{16}$$

36. (c) : $W_{ex} = 6.2 \text{ eV}$

$$K_{\max} = 5 \text{ eV}; \therefore h\nu = 11.2 \text{ eV}$$

$$\therefore \lambda = \frac{hc}{E} = \frac{12400 \text{ eV \AA}}{11.2 \text{ eV}} = 1107 \text{ \AA}$$

This wavelength is in the ultraviolet region.

$$\mathbf{37. (c) :} \lambda = \frac{h}{10^{-6} \text{ kg} \times v}$$

$$= \frac{h}{9.1 \times 10^{-31} \text{ kg} \times 3 \times 10^6 \text{ m/s}}$$

$$\therefore v = 2.7 \times 10^{18} \text{ m/s.}$$

38. (a) : Collisions of the charged particles with the atoms in the gas.

39. (a) : Electron travelling in a magnetic field perpendicular to its velocity - circular path.

40. (d) : Power of monochromatic light beam is $P = Nh\nu$ where N is the number of photons emitted per second.

Power $P = 2 \times 10^{-3} \text{ W}$

Energy of one photon $E = h\nu$

$$= 6.63 \times 10^{-34} \times 6 \times 10^{14} \text{ J}$$

Number of photons emitted per second,

$$N = \frac{P}{E}$$

$$= \frac{2 \times 10^{-3}}{6.63 \times 10^{-34} \times 6 \times 10^{14}} = 0.05 \times 10^{17} = 5 \times 10^{15}$$

41. (d) : For a light source of power P watt, the intensity at a distance d is given by

$$I = \frac{P}{4\pi d^2}$$

where we assume light to spread out uniformly in all directions *i.e.* it is a spherical source.

$$\therefore I \propto \frac{1}{d^2} \quad \text{or} \quad \frac{I_1}{I_2} = \frac{d_2^2}{d_1^2}$$

$$\text{or, } \frac{I_1}{I_2} = \left(\frac{1}{0.5} \right)^2 \quad \text{or, } \frac{I_1}{I_2} = 4 \quad \text{or, } I_2 = \frac{I_1}{4}$$

In a photoelectric emission, the number of photoelectrons liberated per second from a photosensitive metallic surface is proportional to the intensity of the light. When a intensity of source is reduced by a factor of four, the number of photoelectrons is also reduced by a factor of 4.

42. (c) : The photoelectric current is directly proportional to the intensity of illumination. Therefore a change in the intensity of the incident radiation will change the photocurrent also.

43. (a) : Let K and K' be the maximum kinetic energy of photoelectrons for incident light of frequency ν and 2ν respectively.

According to Einstein's photoelectric equation,

$$K = h\nu - E_0 \quad \dots \text{(i)}$$

$$\text{and } K' = h(2\nu) - E_0 \quad \dots \text{(ii)}$$

$$= 2h\nu - E_0 = h\nu + h\nu - E_0$$

$$K' = h\nu + K \quad [\text{using (i)}]$$

44. (c)

45. (a) : Energy of photon $E = 1 \text{ MeV}$ Momentum of photon $p = E/c$

$$\therefore p = \frac{E}{c} = \frac{1 \times 10^6 \times 1.6 \times 10^{-19} \text{ J}}{3 \times 10^8 \text{ ms}^{-1}} = 0.53 \times 10^{-21}$$

$$\approx 5 \times 10^{-22} \text{ kg m/s.}$$

46. (b)

47. (c) : K.E. = $h\nu - W$

$$\text{i.e. } \frac{1}{2}mv_{\text{max}}^2 = h\nu - W$$

$$\Rightarrow \frac{1}{2}m \times (4 \times 10^6)^2 = 2h\nu_0 - h\nu_0$$

$$\text{or, } \frac{1}{2}m \times (4 \times 10^6)^2 = h\nu_0$$

Another case, $2h\nu_0 \rightarrow 5h\nu_0$

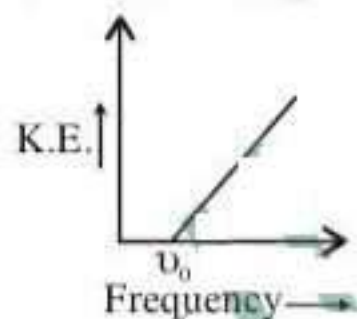
$$\frac{1}{2}mv_{\text{max}}^2 = 4h\nu_0$$

$$\Rightarrow \frac{1}{2}mv_{\text{max}}^2 = 4 \times \frac{1}{2}m \times (4 \times 10^6)^2$$

$$\Rightarrow v_{\text{max}}^2 = 64 \times 10^{12} \Rightarrow v_{\text{max}} = 8 \times 10^6 \text{ m/s.}$$

48. (d) : The maximum kinetic energy of photoelectron ejected is given by

$$\text{K.E.} = h\nu - W = h\nu - h\nu_0$$



where work function depends on the type of material. If the frequency of incident radiation is greater than ν_0 only then the ejection of photoelectrons start. After that as frequency increases kinetic energy also increases.

49. (d) : Photoelectric current $I \propto$ intensity of light

$$\text{and intensity} \propto \frac{1}{(\text{distance})^2}$$

$$\therefore I \propto \frac{1}{(\text{distance})^2}$$

50. (c)

51. (d) : The value of Planck's constant is $6.63 \times 10^{-34} \text{ J-sec.}$

52. (d) : de Broglie wavelength for a particle is given

by $\lambda = \frac{h}{p} = \frac{h}{mv}$, where m , v and p are the mass,

velocity and momentum respectively. h is Planck's constant. Now, since all the particles are moving with same velocity, the particle with least mass will have maximum de-Broglie wavelength. Out of the given four particles (proton, α -particles, i.e. He nucleus and β -particles, i.e. electrons) β -particles has the lowest mass and therefore it has maximum wavelength.

53. (b)

54. (b) : Cathode rays are basically negatively charged particles (electrons). If the cathode rays are allowed to pass between two plates kept at a difference of potential, the rays are found to be deflected from the rectilinear path. The direction of deflection shows that the rays carry negative charges.

55. (a)

$$56. (a) : e\vec{E} = e\vec{v} \times \vec{B} \quad \therefore v = \frac{|E|}{|B|}$$

57. (b) : Intensity becomes 4 times. So number increases.

58. (a)

59. (a)

60. (a) : K.E. = $1.6 \times 10^{-19} \times 1 = 1 \text{ eV.}$

$$61. (a) : \phi = h\nu = \frac{hc}{\lambda}$$

$$\Rightarrow \lambda = \frac{hc}{\phi} = \frac{1242 \text{ eV. nm}}{4.125} \approx 3000 \text{ \AA}$$

62. (c) : If the intensity of light of a given frequency is increased, then the number of photons striking the surface per second will increase in the same ratio. This increased number of photons strikes more electrons of metals and hence number of photoelectrons emitted through the surface increase and hence photoelectric current increases.

63. (d) : According to Einstein's photoelectric equation,

$$\frac{1}{2}mv^2 = \frac{hc}{\lambda} - W_0 \quad \text{or, } \frac{hc}{\lambda} = \frac{1}{2}mv^2 + W_0$$

$$\text{and } \frac{1}{2}mv_1^2 = \frac{hc}{3\lambda/4} - W_0 = \frac{4}{3} \left(\frac{1}{2}mv^2 + W_0 \right) - W_0$$

So, v_1 is greater than $v(4/3)^{1/2}$.

64. (a) : Since the emission of photoelectrons is directly proportional to the intensity of the incident light, therefore photocurrent increases with the intensity of light.

65. (c) : Potential difference (V) = 100 volts.
Kinetic energy of an electron (K.E.)

$$= eV = (1.6 \times 10^{-19}) \times 100 = 1.6 \times 10^{-17} \text{ joule.}$$

66. (c) : Kinetic energy (E) = 100 eV;
Mass of electron (m) = 9.1×10^{-31} kg;

$$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J and}$$

Planck's constant (h) = 6.6×10^{-34} J-s.

Energy of an electron (E) = $100 \times (1.6 \times 10^{-19})$ J

$$\text{or } \lambda = \frac{h}{\sqrt{2mE}} = \frac{6.6 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 100 \times 1.6 \times 10^{-19}}}$$

$$= 1.2 \times 10^{-10} \text{ m} = 1.2 \text{ \AA.}$$

67. (a)

68. (a) : The kinetic energy of an electron

$$\frac{1}{2} \times mv^2 = eV$$

$$\text{or final velocity of electron } (v) = \sqrt{\frac{2eV}{m}}$$

69. (c) : Energy of the photon $E = \frac{hc}{\lambda}$ or $\lambda = \frac{hc}{E}$,
where λ is the wavelength.

70. (*) : The velocity of a photon in vacuum is a constant. $c = v\lambda$. But $c =$ constant and one cannot say that it is proportional to v or λ but only $c = v\lambda$. In media, for a particular medium, v remain the same, velocity changes. Therefore λ changes. The question is wrong.

71. (d) : Momentum of electrons (p_e) = $\sqrt{2meV}$ and
momentum for proton (p_p) = $\sqrt{2MeV}$

$$\text{Therefore, } \frac{\lambda_p}{\lambda_e} = \frac{h/p_p}{h/p_e} = \frac{p_e}{p_p} = \frac{\sqrt{2meV}}{\sqrt{2MeV}} = \sqrt{\left(\frac{m}{M}\right)}$$

$$\text{Therefore } \lambda_p = \lambda \sqrt{\left(\frac{m}{M}\right)}$$

72. (a) : Wavelength (λ) = $\frac{h}{mv} = \frac{h}{p}$. Therefore for same wavelength of electrons and photons, the momentum should be same.

$$73. (b) : W_0 = \frac{hc}{\lambda_0} \text{ or } W_0 \propto \frac{1}{\lambda_0};$$

$$\Rightarrow \frac{W_1}{W_2} = \frac{\lambda_2}{\lambda_1} = \frac{600}{300} = 2$$

74. (a) : Photoelectric current is directly proportional to the intensity of incident light.

75. (a) : Momentum of the photon = $\frac{h\nu}{c}$

76. (a) : The work function has no effect on photoelectric current so long as $h\nu > W_0$. The photoelectric current is proportional to the intensity of incident light. Since there is no change in the intensity of light, hence $I_1 = I_2$.

$$77. (d) : h\nu = W + \frac{1}{2}mv^2 \text{ or } \frac{hc}{\lambda} = W + \frac{1}{2}mv^2$$

Here $\lambda = 3000 \text{ \AA} = 3000 \times 10^{-10} \text{ m}$

and $W = 1 \text{ eV} = 1.6 \times 10^{-19} \text{ joule}$

$$\therefore \frac{(6.6 \times 10^{-34})(3 \times 10^8)}{3000 \times 10^{-10}} = (1.6 \times 10^{-19}) + \frac{1}{2} \times (9.1 \times 10^{-31})v^2$$

Solving we get $v \cong 10^6 \text{ m/s}$

78. (b) : Here, $\frac{hc}{\lambda} = 10^3 \text{ eV}$ and $h\nu = 10^6 \text{ eV}$

$$\text{Hence, } \nu = \frac{10^3 c}{\lambda} = \frac{10^3 \times 3 \times 10^8}{1.24 \times 10^{-9}}$$

$$= 2.4 \times 10^{20} \text{ Hz}$$

$$79. (c) : \gamma = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{m_0}{\sqrt{c^2 - (0.8c)^2}} = \frac{5m_0}{3}$$

80. (a) : No. of photons emitted per sec,

$$n = \frac{\text{Power}}{\text{Energy of photon}}$$

$$= \frac{P}{h\nu} = \frac{10000}{6.6 \times 10^{-34} \times 880 \times 10^3} = 1.72 \times 10^{31}$$

81. (a) : Momentum of the photon = $\frac{h\nu}{c}$

$$\Rightarrow \frac{c}{\nu} = \frac{h}{p} = \lambda$$

$$\nu = \frac{c}{\lambda} = \frac{cp}{h} = 3 \times 10^8 \times \frac{3.3 \times 10^{-29}}{6.6 \times 10^{-34}}$$

$$= 1.5 \times 10^{13} \text{ Hz}$$

where, ν = frequency of radiation

82. (b) : Kinetic energy of fastest electron

$$= E - W_0 = 6.2 - 4.2 = 2.0 \text{ eV}$$

$$= 2 \times 1.6 \times 10^{-19} = 3.2 \times 10^{-19} \text{ J}$$

83. (a) : de Broglie wavelength, $\lambda = \frac{h}{p} = \frac{h}{mv}$

84. (b) : Energy of a photon $E = h\nu = \frac{hc}{\lambda}$

85. (b) : When a metal is heated, electrons are ejected out of it, which are called thermions.

$$86. (a) : W_0 = \frac{hc}{\lambda_0}$$

$$= \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{5000 \times 10^{-10}} = 4 \times 10^{-19} \text{ J}$$

