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PHYSICS

14.DUAL NATURE OF RADIATION AND MATTER

Single Correct Answer Type

1. What is the de-Broglie wavelength of the electron accelerated through potential difference of 100 V?
   a) 12.27 Å b) 1.22 Å
   c) 0.1227 Å d) 0.001227 Å

2. According to Einstein's photoelectric equation, the graph of KE of the photoelectron emitted from the metal versus the frequency of the incident radiation gives a straight line graph, whose slope
   a) depends on the intensity of the incident radiation
   b) depends on the nature of the metal and also on the intensity of incident radiation
   c) is same for all metals and independent of the intensity of the incident radiation
   d) depends on the nature of the metal

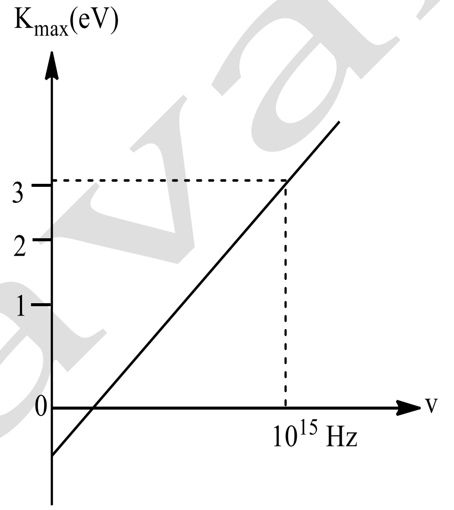
3. Which of the following is not the property of the photons?
   a) Momentum b) Energy
   c) Charge d) Velocity

4. A metal Surface of work function 1.07 eV is irradiated with light of wavelength 332 nm. The retarding potential required to stop the escape of photoelectrons is
   a) 1.07 eV b) 2.68 eV
   c) 3.7 eV d) 4.81 eV

5. The momentum of a photon of energy 1MeV (in $kg - ms^{-1}$), will be
   a) 0.33×10^{6} b) 7×10^{-24}
   c) 10^{-22} d) 5×10^{-22}

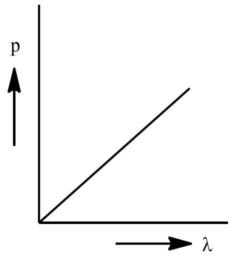
6. The de-Broglie wavelength of a photon is twice the de-Broglie wavelength of an electron. The velocity of the electron is $v_\theta = \frac{c}{100}$, then
   a) $\frac{E_e}{E_{ph}} = 10^{-4}$ b) $\frac{E_e}{E_{ph}} = 10^{-2}$
   c) $\frac{p_e}{m_e c} = 10^{-3}$ d) $\frac{p_e}{m_e c} = 10^{-4}$

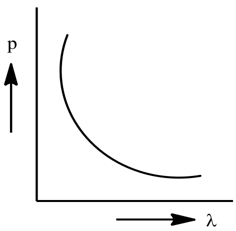
7. Figure given below is representing a graph of kinetic energy of most energetic photoelectrons K_{max} (in eV) and frequency v for a metal used as cathode in photoelectric experiment. The threshold frequency of light for the photoelectric emission from the metal is

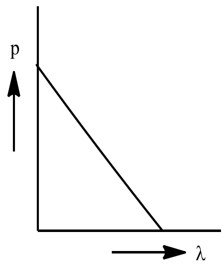


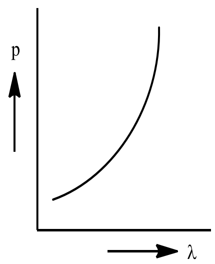
   a) 4×10^{14}Hz b) 3.5×10^{14}Hz
   c) 2.0×10^{14}Hz d) 2.7×10^{14}Hz

8. Which of the following figures represent the variation of particle momentum and the associated de-Broglie wavelength?

a) 

b) 

c) 

d) 

9. The voltage applied to an electron microscope to produce electrons of wavelength 0.50 Å is
   a) 602 V b) 50 V
   c) 138 V d) 812 V

10. 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 metal(S) which will emit photoelectrons for a radiation of wavelength 4100 A is/are

a) A only b) A and B
c) Both (a) and (b) d) Neither (a) nor (b)

11. When certain metal surface is illuminated with a light of wavelength λ, the stopping potential is V. When the same surface is illuminated by light of wavelength 2λ, the stopping potential is $\left(\frac{V}{3}\right)$. The threshold wavelength for the surface is

a) $\frac{8\lambda}{3}$ b) $\frac{4\lambda}{3}$
c) 4λ d) $6\ \lambda$

12. A photosensitive metallic surface has work function ϕ. If photon of energy $3\ \phi$ fall on this surface, the electron comes out with a maximum velocity of $6\times10^{6}\ \mathrm{ms}^{-1}$. When the photon energy is increased to $9\ \phi$, then maximum velocity of photoelectron will be

a) $12\times10^{6}\ \mathrm{ms}^{-1}$ b) $6\times10^{6}\ \mathrm{ms}^{-1}$
c) $3\times10^{6}\ \mathrm{ms}^{-1}$ d) $24\times10^{6}\ \mathrm{ms}^{-1}$

13. Light of wavelength λ which is less than threshold wavelength is incident on a photosensitive material. If incident wavelength is decreased, so that emitted photoelectrons are moving with same velocity, then stopping potential will

a) increase b) decrease
c) be zero d) become exactly half

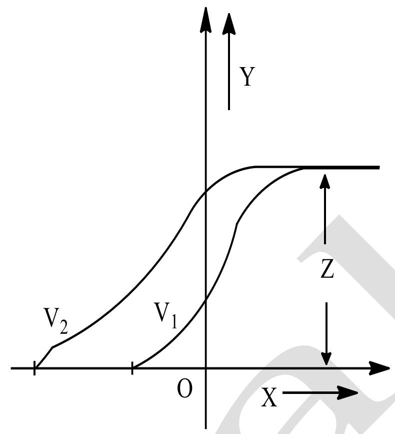
14. In a photoelectric effect measurement, the stopping potential for a given metal is found to be V_0 volt when radiation of wavelength λ_0 is used. If radiation of wavelength $2\lambda_0$ is used with the same metal, then the stopping potential (in volt) will be

a) $\frac{V_0}{2}$ b) $2V_0$
c) $V_0+\frac{hc}{2e\lambda_0}$ d) $V_0-\frac{hc}{2\theta\lambda_0}$

15. Silver has a work function of 4.7 eV. When ultraviolet light of wavelength 100 nm is incident on it, a potential of 7.7 V is required to stop the photoelectrons from reaching the collector plate. How much potential will be required to stop photoelectrons, when light of wavelength 200 nm is incident on it?

a) 15.4 V b) 2.35 V
c) 3.85 V d) 1.5 V

16. A student plot a graph while performing an experiment on photoelectric affect using an evacuated glass tube, for light radiation of same intensity at various frequencies as shown below.



Here ,

a) X → Photoelectric current; Y → Retarding potential; Z → Stopping potential
b) X → Retarding plate potential; Y → Photocurrent; Z → Stopping potential
c) X → Collector plate potential; Y → Photocurrent; Z → Saturation current
d) X → Retarding plate potential; Y → Photocurrent; Z → Saturation current

17. An α-particle and a proton are accelerated from rest by a potential difference of 100 V. After this, their de-Broglie wavelengths are λ_α and λ_p, respectively. The ratio $\frac{\lambda_p}{\lambda_\alpha}$, to the nearest integer, is

a) 3 b) 4
c) 2 d) 45

18. The energy of a photon is equal to the kinetic energy of a proton. If λ_1 is the de-Broglie wavelength of a proton, λ_2 the wavelength associated with the photon and if the energy of the photon is E, then (λ_1/λ_2) is proportional to

a) E^4 b) $E^{1/2}$
c) E^2 d) E

19. When photons of energy hv fall on a metal plate of work function W_0, photoelectrons of maximum kinetic energy K are ejected. If the frequency of the radiation is doubled, the maximum kinetic energy of the ejected photoelectrons will be

a) $K+W_0$ b) $K+hv$
c) K d) 2K

20. Two particles A_1 and A_2 of masses m_1 and m_2

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$(m_1 > m_2)$ have the same de-Broglie wavelength, then

a) their momenta are the same
b) their energies are the same
c) momenta of A_1 is less than the momenta of A_2
d) energy of A_1 is more than energy of A_2

21. The work function for aluminium is 4.125 eV. The cut-off wavelength for photoelectric effect for aluminium will be
a) 420 nm
b) 350 nm
c) 300 nm
d) 200 nm

22. The de-Broglie wavelength of a neutron in thermal equilibrium with heavy water at a temperature T (kelvin) and mass m, is
a) $\frac{h}{\sqrt{mkT}}$
b) $\frac{h}{\sqrt{3mkT}}$
c) $\frac{2h}{\sqrt{3mkT}}$
d) $\frac{2h}{\sqrt{mkT}}$

23. Calculate the energy of a photon with momentum 3.3×10^{-13} Kg-ms^{-1}.(Take, Planck's constant to be 6.6×10^{-34} J-s)
a) 7.3×10^4 J
b) 9.9×10^{-5} J
c) 1.3×10^5 J
d) 8.1×10^3 J

24. A certain metallic surface is illuminated with monochromatic light of wavelength λ. The stopping potential for photoelectric 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 photoelectric effect is
a) 6λ
b) 4λ
c) $\frac{\lambda}{4}$
d) $\frac{\lambda}{6}$

25. When intensity of incident light increases,
a) photocurrent increases
b) photocurrent decreases
c) kinetic energy of emitted photoelectrons increases
d) kinetic energy of emitted photoelectrons decreases

26. The maximum velocity of the photoelectron emitted by the metal surface is v. Charge and mass of the photoelectron is denoted by e and m, respectively. The stopping potential (in volt) is
a) $\frac{v^2}{2\left(\frac{e}{m}\right)}$
b) $\frac{v^2}{\left(\frac{m}{e}\right)}$
c) $\frac{v^2}{2\left(\frac{m}{e}\right)}$
d) $\frac{v^2}{\left(\frac{e}{m}\right)}$

27. The wavelength λ_e of an electron and λ_p of a photon of same energy E are related by
a) $\lambda_p \propto \lambda_e^2$
b) $\lambda_p \propto \lambda_\theta$
c) $\lambda_p \propto \sqrt{\lambda_e}$
d) $\lambda_p \propto \frac{1}{\sqrt{\lambda_e}}$

28. If the linear momentum of a particle is 2.2×10^4 kg − ms^{-1}, then what will be its de-Broglie wavelength? (Take, $h = 6.6 \times 10^{-34}$ J − s)
a) 3×10^{-39} m
b) 3×10^{-29} nm
c) 6×10^{-29} m
d) 6×10^{-29} nm

29. The work function for Al, K and P t is 4.28 eV, 2.30 eV and 5.65 eV, respectively , Their respective threshold frequencies would be
a) Pt > Al > K
b) Al > Pt >K
c) K > Al > Pt
d) Al > K > Pt

30. The energy of an electron having de-Broglie wavelength λ is (where, h = Planck's constant, m = mass of electron)
a) $\frac{h}{2m\lambda}$
b) $\frac{h^2}{2m\lambda^2}$
c) $\frac{h^2}{2m^2\lambda^2}$
d) $\frac{h^2}{2m^2\lambda}$

31. If the frequency of light in a photoelectric experiment is doubled, then stopping potential will
a) be doubled
b) halved
c) become more than double
d) become less than double

32. When light of wavelength λ is incident on photosensitive surface, the stopping potential is V.
When light of wavelength 3 λ is incident on same surface, the stopping potential is $\frac{V}{6}$.
Threshold wavelength of the surface is
a) 2 λ
b) 3 λ
c) 4 λ
d) 5 λ

33. The dual nature of light is exhibited by
a) diffraction and photoelectric effect
b) photoelectric effect
c) refraction and interference
d) diffraction and reflection

34. When the kinetic energy of an electron is increased, the wavelength of the associated wave will
a) increase
b) decrease
c) wavelength does not depends upon
d) None of the above

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kinetic energy

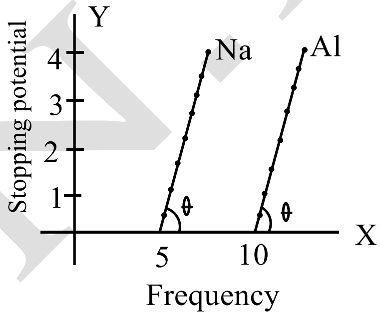
35. Energy of the incident photon on the metal surface is 3W and then 5W, where W is the work function for that metal .The ratio of velocities of emitted photoelectrons is
a) 1 : 4 b) 1 : 2
c) $1 : \sqrt{2}$ d) 1 : 1

36. When photon of energy 4.25eV strike the surface of a metal A, the ejected photoelectrons have maximum kinetic energy $T_A \theta V$ and de-Broglie wavelength λ_A. The maximum kinetic energy of photoelectrons liberated from another metal B by photon of energy 4.70 eV is $T_B = (T_A - 1.5)$eV. If the de-Broglie wavelength of these photoelectron is $\lambda_B = 2\lambda_A$, then
a) the work function of A is 3.25 eV b) the work function of B is 2.20 eV
c) $T_A = 3.00$ eV d) $T_B = 0.5$ eV

37. Light of wavelength λ strikes a photoelectric surface and electrons are ejected with an energy E. If E is to be increased to exactly twice its original value, the wavelength changes to λ′, where
a) λ′ is less than $\frac{\lambda}{2}$ b) λ′ is greater than $\frac{\lambda}{2}$
c) λ′ is greater than $\frac{\lambda}{2}$ but less than λ d) λ′ is exactly equal to $\frac{\lambda}{2}$

38. An electron is accelerated under a potential difference of 182 V. The maximum velocity of electron will be (Take, charge of an electron is 1.6×10^{-19}C and its mass is 9.1×10^{-31} kg)
a) 5.65×10^6 ms^{-1} b) 4×10^6 ms^{-1}
c) 8×10^6 ms^{-1} d) 16×10^6 ms^{-1}

39. From the figure, describing photoelectric effect, we may infer correctly that



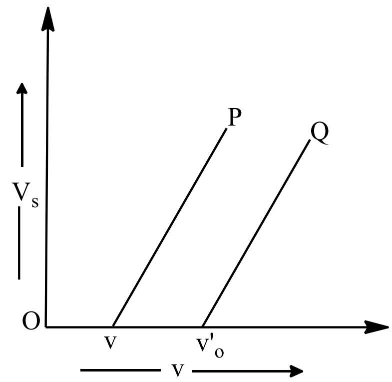
a) Na and Al both have the same threshold frequency b) maximum kinetic energy for both the metals depend linearly on the frequency
c) the stopping potentials are different for Na and Al for the same change in frequency d) Al is a better photosensitive material than Na

40. If the work function for a certain metal is 3.2×10^{-19} J and it is illuminated with light of frequency $v = 8 \times 10^{14}$ Hz, the maximum kinetic energy of the photoelectron would be
a) 2.1×10^{-19} J b) 3.2×10^{-19} J
c) 5.3×10^{-19} J d) 8.5×10^{-19} J

41. What is de-Broglie wavelength of electron having energy 10 keV?
a) 0.12 Å b) 12 Å
c) 1.22 Å d) None of these

42. Photon and electron are given equal energy (10^{-2} J) Wavelengths associated with photon and electron are λ_p and λ_e, then correct statement will be
a) $\lambda_p > \lambda_\theta$ b) $\lambda_p < \lambda_\theta$
c) $\lambda_p = \lambda_e$ d) $\frac{\lambda_e}{\lambda_p} = c$

43. The graph of stopping potential V_s against frequency v of incident radiation is plotted for two different metals P and Q as shown in the graph. ϕ_P and ϕ_Q are work functions of P and Q respectively, then



a) $\phi_P > \phi_Q$ b) $\phi_P < \phi_Q$
c) $\phi_P = \phi_Q$ d) $v_0' < v_0$

44. Work function for caesium metal is 2.14 eV. Let a beam of light of frequency 6×10^{14} Hz is incident over the metal surface.
Now, match the following columns and mark the correct option from the codes given below.

Column I	Column II
A. Maximum KE of emitted photoelectrons (in eV)	1. 348

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B. Minimum KE of emitted photoelectrons (in eV)	2.	345
C. Stopping potential of material (in mV) is	3.	0.345
D. Maximum speed of the emitted photoelectrons(in kms^{-1})	4.	0

a) A B C D
4 3 2 1

b) A B C D
3 4 2 1

c) A B C D
3 1 4 2

d) A B C D
2 1 4 3

45. The frequency of the incident light falling on a photosensitive metal plate is doubled, the kinetic energy of the emitted photoelectron is

a) double the earlier value
b) unchanged
c) more than doubled
d) less than doubled

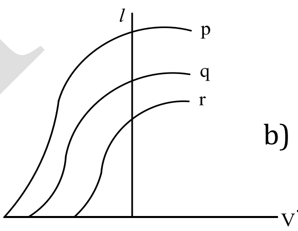
46. The difference between kinetic energies of photoelectrons emitted from a surface by light of wavelength 2500 Å and 5000 Å will be

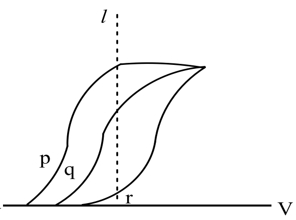
a) 1.67 eV
b) 2.47 eV
c) 3.96 eV
d) 3.96×10^{-19}eV

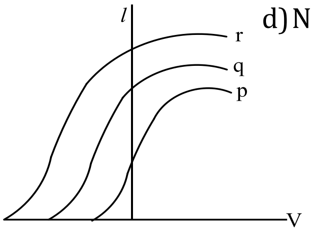
47. The ratio of momenta of an electron and an α-particle which are accelerated from rest by a potential difference of 100 V is

a) 1
b) $\sqrt{\frac{2m_e}{m_\alpha}}$
c) $\sqrt{\frac{m_e}{m_\alpha}}$
d) $\sqrt{\frac{m_e}{2m_\alpha}}$

48. Photoelectric effect experiments are performed using three different metal plates p, q and r having work functions $\phi_p = 2.0$ eV, $\phi_q = 2.5$ eV and $\phi_r = 3.0$ eV, respectively. A light beam containing wavelengths of 550 nm, 450 nm and 350 nm with equal intensities illuminates each of the plates. The correct $l - V$ graph for the experiment is

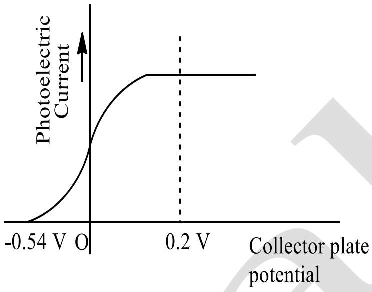
a) 

b) 

c) 

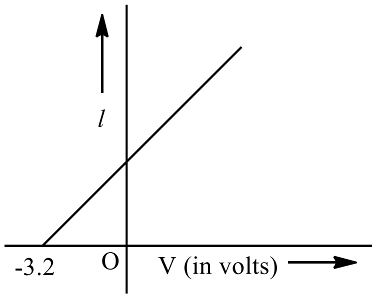
d) None of these

49. The value of stopping potential V_0 from the give



a) -0.54 V
b) 0.54 V
c) 0.2 V
d) -0.2 V

50. In a photoelectric experiment, the relation between applied potential difference between cathode and anode V and the photoelectric current / was found to be shown in graph below.
If Planck's constant $h = 6.6 \times 10^{-34}$ J − s, the frequency of incident radiation would be nearly (in s^{-1})



a) 0.436×10^{18}
b) 0.436×10^{17}
c) 0.775×10^{15}
d) 0.775×10^{16}

51. An electron of mass m and a photon have same energy E. The ratio of de-Broglie wavelengths associated with them is (c being velocity of light)

a) $\left(\frac{E}{2m}\right)^{1/2}$
b) $c(2mE)^{1/2}$
c) $\frac{1}{c}\left(\frac{2m}{E}\right)^{1/2}$
d) $\frac{1}{c}\left(\frac{E}{2m}\right)^{1/2}$

52. According to de-Broglie hypothesis, the wavelength associated with moving electron of mass m is λ_e. Using mass-energy relation and Planck's quantum theory, the wavelength associated with photon is λ_p. If the energy (E) of electron and photon is same, then relation between λ_e and λ_p is

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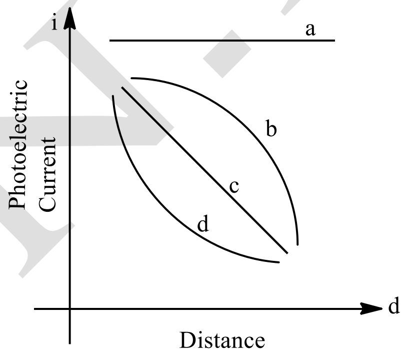
a) $\lambda_p \propto \lambda_e$
b) $\lambda_p \propto \lambda_e^2$
c) $\lambda_p \propto \sqrt{\lambda_\theta}$
d) $\lambda_p \propto \frac{1}{\lambda_e}$

53. If the maximum kinetic energy of emitted electrons in photoelectric effect is 3.2×10^{-19} J and the work function for metal is 6.63×10^{-19} J, then stopping potential and threshold wavelength respectively are
(Planck's constant, $h = 6.63 \times 10^{-34}$ J − s, velocity of light, $c = 3 \times 10^8$ ms^{-1}, charge on electron $= 1.6 \times 10^{-19}$C)
a) 4 V, 6000Å
b) 3 V, 4000 Å
c) 2 V, 3000Å
d) 1 V, 1000Å

54. A metal surface is illuminated by light of given intensity and frequency to cause photoemission. If the intensity of illumination is reduced to one-fourth of its original value, then the maximum KE of the emitted photoelectrons would be
a) twice the original value
b) four times the original value
c) one-fourth of the original value
d) unchanged

55. The act of photoelectric effect taking place with a certain photosensitive metal depends upon
(i)frequency and
(ii)intensity of the incident radiation.
a) Both (i) and(ii) are correct
b) only (i) is correct
c) Only (ii) is correct
d) Neither (i) nor (ii) is correct

56. A point source of light is used in an experiment of photoelectric effect. Which of the following curves best represents the variation of photoelectric current i with distance d of the source from the emitter?



a) a
b) b
c) c
d) d

57. The de-Broglie wavelength of the electron in the ground state of the hydrogen atom is (Take, radius of the first orbit of hydrogen atom = 0.53 Å)
a) 1.67 Å
b) 3.33 Å
c) 1.06 Å
d) 0.53 Å

58. A particle of mass 1mg has the same wavelength as an electron moving with a velocity of 3×10^6 ms^{-1}. The velocity of the particle is
a) 3×10^{-31} ms^{-1}
b) 2.7×10^{-21} ms^{-1}
c) 2.7×10^{-18} ms^{-1}
d) 9×10^{-2} ms^{-1}

59. For photoelectric emission from certain metal, the cut-off frequency is v. If radiation of frequency 2v impinges on the metal plate, the maximum possible velocity of the emitted electron will be (m is the electron mass)
a) $\sqrt{\frac{hv}{(2m)}}$
b) $\sqrt{\frac{hv}{m}}$
c) $\sqrt{\frac{2hv}{m}}$
d) $2\sqrt{\frac{hv}{m}}$

60. The energy of a photon corresponding to the visible light of maximum wavelength is approximately
a) 1 eV
b) 1.6 eV
c) 3.2 eV
d) 7 eV

61. Photoelectric emission occurs only when the incident light has more than a certain minimum
a) wavelength
b) intensity
c) frequency
d) power

62. A parallel beam of light is incident normally on a plane surface absorbing 40% of the light and reflecting the rest. If the incident beam carries 60 W of power, the force exerted by it on the surface is
a) 3.2×10^{-8} N
b) 3.2×10^{-7} N
c) 5.12×10^{-7} N
d) 5.12×10^{-8} N

63. Monochromatic light of frequency 6.0×10^{14} Hz is produced by a laser. The power emitted is 2×10^{-3} W. The number of photons emitted on the average, by the source per second is
a) 5×10^{15}
b) 5×10^{16}
c) 5×10^{17}
d) 5×10^{14}

64. On a photosensitive material, when frequency of incident radiation is increased by 30%, kinetic energy of emitted photoelectrons increases from 0.4 eV to 0.9 eV. The work function of the surface is
a) 1 eV
b) 1.267 eV
c) 1.4 eV
d) 1.8 eV

65. An electron of mass m_e and a proton of mass m_p are moving with the same speed. The ratio of their de-Broglie wavelength λ_θ/λ_p is

a) 918 b) $\frac{1}{1836}$

c) 1836 d) 1

66. Light of wavelength 4000 Å is incident on a metal plate whose work function is 2 eV. The maximum KE of the emitted photoelectron would be

a) 0.5 eV b) 1.1 eV

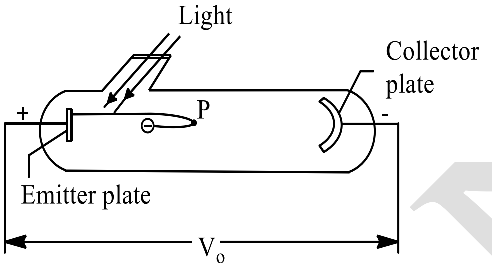
c) 1.5 eV d) 2.0 eV

67. For a certain metal, $v = 2v_0$ and the electrons come out with a maximum velocity of $4 \times 10^6\ ms^{-1}$. If the value of $v = 5\ v_0$, then maximum velocity of photoelectrons will be

a) $2 \times 10^7\ ms^{-1}$ b) $8 \times 10^6\ ms^{-1}$

c) $2 \times 10^6\ ms^{-1}$ d) $8 \times 10^5\ ms^{-1}$

68. In photoelectric effect experiment, collector plate is made negative with respect to emitter plate as shown in figure below till it reach a certain potential V_0 when photocurrent is zero.



If K indicates kinetic energy of an emitted photoelectron, then at point P ,

a) $K > eV_0$ b) $K < eV_0$

c) $K = ev_0$ d) $O \le K \le eV_0$

69. If 5% of the energy supplied to a bulb is irradiated as visible light, how many quanta are emitted per second by a 100 W lamp? (Assume, wavelength of visible light as 5.6×10^{-5} cm)

a) 1.4×10^{19} b) 3×10^3

c) 1.4×10^{-19} d) 3×10^4

70. A point source of light is used in a photoelectric effect. If the source is removed farther from the emitting metal, then the stopping potential

a) will increase b) will decrease

c) will remain constant d) will either increase or decrease

71. The maximum kinetic energy of the photoelectrons depends only on

a) potential b) frequency

c) incident angle d) pressure

72. An electron of mass m and charge e initially at rest gets accelerated by a constant electric field E. The rate of change of de-Broglie wavelength of the electron at time t ignoring relativistic effect is

a) $\frac{-h}{eEt^2}$ b) $\frac{-eEt}{h}$

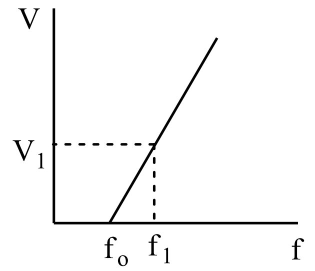
c) $\frac{-mh}{eEt^2}$ d) $\frac{-h}{eE}$

73. Electrons with de-Broglie wavelength λ fall on the target in an X-ray tube. The cut-off wavelength of the emitted X-rays 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) $\lambda_0 = \lambda$

74. In a photoelectric experiment, the potential difference V that must be maintained between the illuminated surface and the collector so as just to prevent any electron from reaching the collector is determined for different frequencies f of the incident illumination. The graph obtained is shown in the figure. The maximum kinetic energy of the electrons emitted at frequency f_1 is



a) $h\ f_1$ b) $\frac{V_1}{(f_1 - f_0)}$

c) $h(f_1 - f_0)$ d) $eV_1(f_1 - f_0)$

75. Light of wavelength 4000 Å is incident on a sodium surface for which the threshold wavelength of photoelectrons is 5420 Å. The work function of sodium is

a) 0.57 eV b) 1.14 eV

c) 2.29 eV d) 4.58 eV

76. Ultraviolet light of wavelength 300 nm and intensity $1.0 Wm^{-2}$ falls on the surface of a photosensitive material. If one per cent of the incident photons produce photoelectrons, then the number of photoelectrons emitted from an area of $1.0\ cm^2$ of the surface is nearly

a) $9.61 \times 10^{14}\ s^{-1}$ b) $4.12 \times 10^{13}\ s^{-1}$

c) $1.51 \times 10^{12}\ s^{-1}$ d) $2.13 \times 10^{11}\ s^{-1}$

77. The light of wavelength λ incident on the

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surface of metal having work function ϕ emits the electrons. The maximum velocity of electrons emitted is (c = velocity of light, h = Planck's constant, m = mass of electron)

a) $\left[\frac{2(hv-\phi)\lambda}{mc}\right]$ b) $\left[\frac{2(hc-\lambda\phi)}{m\lambda}\right]^{1/2}$

c) $\left[\frac{2(hc-\lambda)}{m\lambda}\right]^{1/2}$ d) $\left[\frac{2(hc-\phi)}{m\lambda}\right]$

78. Light of two different frequencies whose photons have energies 1 less eV and 2.5 less eV respectively, successively illuminate a metallic surface whose work function is 0.5 eV. Ratio of maximum speeds of emitted electrons will be

a) 1 : 2 b) 1 : 5

c) 1 : 1 d) 1 : 4

79. Energy of photon whose frequency is 10^{12}MHz, will be

a) 4.14×10^3keV b) 4.14×10^2eV

c) 4.14×10^3MeV d) 4.14×10^3eV

80. The photoelectric threshold wavelength for a metal surface is 6600 A. The work function for this metal is

a) 0.87 eV b) 1.87 eV

c) 18.7 eV d) 0.18 eV

81. The kinetic energy of an electron gets tripled, then the de-Broglie wavelength associated with it changes by a factor

a) $\frac{1}{3}$ b) $\sqrt{3}$

c) $\frac{1}{\sqrt{3}}$ d) 3

82. Radiations of two photons of energies twice and five times the work function of metal are incident successively on the metal surface. The ration of the maximum velocity of the photoelectrons emitted in the two cases will be

a) 1 : 1 b) 1 : 2

c) 1 : 3 d) 1 : 4

83. The de-Broglie wavelength λ of a particle

a) is proportional to mass b) Is proportional to impulse

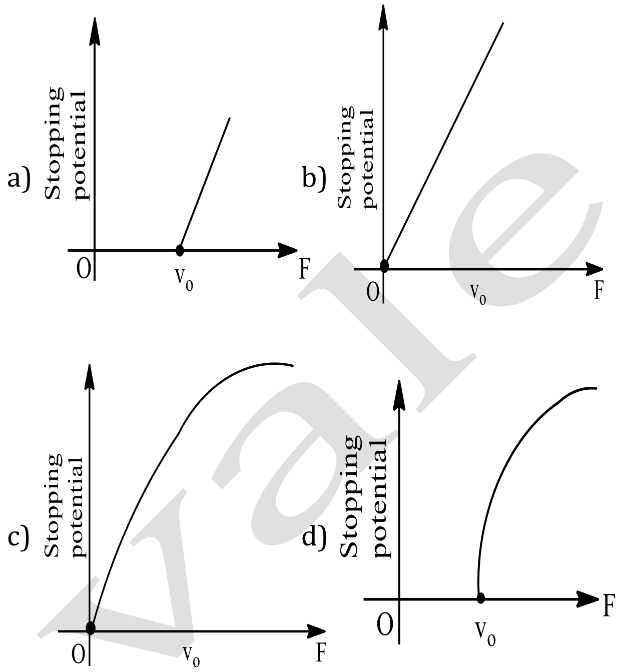
c) is inversely proportional to impulse d) does not depend on impulse

84. What should be the velocity of an electron, so that its momentum becomes equal to that of a photon of wavelength 5200Å?

a) 700 ms^{-1} b) 1000 ms

c) 1400 ms^{-1} d) 2800 ms^{-1}

85. Following graphs show the variation of stopping potential corresponding to the frequency of incident radiation (F) for a given metal. The correct variation is shown in graph (where, v_0 = threshold frequency)



86. If e/m of electron is 1.76×10^{11} Ckg^{-1} and stopping potential is 0.71 V, then the maximum velocity of the photoelectron is

a) 150 kms^{-1} b) 200 kms^{-1}

c) 500 kms^{-1} d) 250 kms^{-1}

87. If n_R and n_V denote the number of photons emitted by a red bulb and violet bulb of equal power in a given time, then

a) $n_B = n_V$ b) $n_R > n_V$

c) $n_R < n_V$ d) $n_R \geq n_V$

88. The work function of a substance is 4.0 eV. The longest wavelength of light that can cause photoelectric emission from this substance is approximately

a) 540 nm b) 400 nm

c) 310 nm d) 220 nm

89. Threshold wavelength for lithium metal is 6250 Å. For photoemission, the wavelength of the incident light must be

a) exactly equal to 6250 Å b) more than 6250 Å

c) equal to or more than 6250 Å d) equal to or less than 6250 Å

90. Variation of photoelectric current with collector plate potential for different intensities I_1 and I_2 (such that $I_1 > I_2$) at a fixed frequency is

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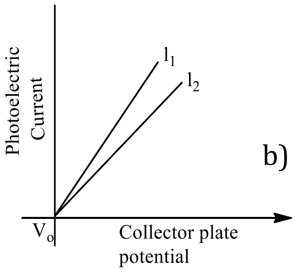
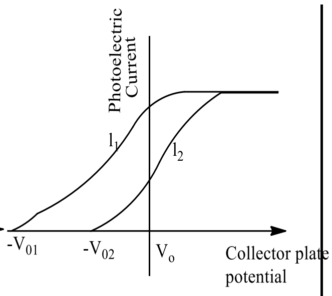
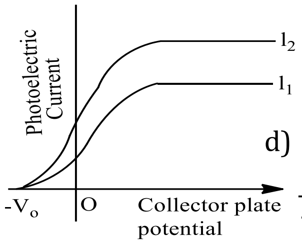
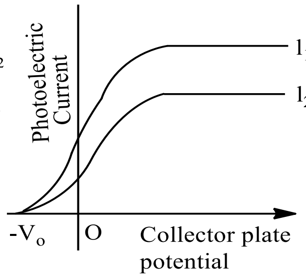
a)


b)


c)


d)


91. When a photon enters glass from air, which one of the following quantity does not change?
 a) velocity b) Wavelength
 c) Momentum d) Energy

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TEST ID: 59
PHYSICS

14.DUAL NATURE OF RADIATION AND MATTER

: ANSWER KEY :

1)	b	2)	c	3)	c	4)	b	49)	a	50)	c	51)	d	52)	a
5)	d	6)	b	7)	d	8)	b	53)	c	54)	d	55)	b	56)	d
9)	a	10)	b	11)	c	12)	a	57)	b	58)	c	59)	c	60)	b
13)	a	14)	d	15)	d	16)	c	61)	c	62)	b	63)	a	64)	b
17)	a	18)	b	19)	b	20)	a	65)	c	66)	b	67)	b	68)	c
21)	c	22)	b	23)	b	24)	b	69)	a	70)	c	71)	b	72)	a
25)	a	26)	a	27)	a	28)	b	73)	a	74)	c	75)	c	76)	c
29)	a	30)	b	31)	c	32)	d	77)	b	78)	a	79)	d	80)	b
33)	a	34)	b	35)	c	36)	d	81)	c	82)	b	83)	c	84)	c
37)	c	38)	c	39)	b	40)	a	85)	a	86)	c	87)	b	88)	c
41)	a	42)	a	43)	b	44)	b	89)	d	90)	d	91)	d		
45)	c	46)	b	47)	d	48)	d								

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14.DUAL NATURE OF RADIATION AND MATTER

: HINTS AND SOLUTIONS :

Single Correct Answer Type

1 **(b)**

The de-Broglie wavelength of an electron is given by

$$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2meV}} = \frac{12.27}{\sqrt{V}} \text{Å}$$

(where, h = Planck's constant)

Here, m = mass of electron, e = electronic charge and V = potential difference with which electron is accelerated.

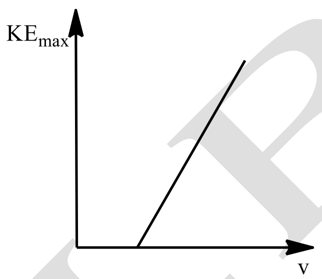
$$\therefore \quad \lambda = \frac{12.27}{\sqrt{100}} \text{Å} = \frac{12.27}{10} \text{Å} = 1.227\text{A}$$

2 **(c)**

According to Einstein's photoelectric equation, $KE_{max} = hv - \phi_0$

Comparing with the equation of straight line y = mx + c,

we get



Slope of graph = h = constant

3 **(c)**

A photon is a particle which has zero charge and zero mass. The energy of photon is

$E = hv$

Here, v = frequency and h = Planck's constant. The momentum of the photon is h/λ and its velocity is the velocity of light c.

So, the charge is not the property of photons.

4 **(b)**

Energy of incident light, $E(eV) = \frac{12375}{3320} = 3.72eV$

We know that, $E = \phi_0 + eV_0$

$$\Rightarrow V_0 = \frac{(E - \phi_0)}{e} = \frac{3.72 - 1.07}{e}$$

$$\Rightarrow V_0 = 2.68 \text{ V}$$

5 **(d)**

Energy of photon is given by $E = \frac{hc}{\lambda}$ ...(i)

where, h is the Planck's constant, c is the velocity of light and λ its wavelength.

de-Broglie wavelength is given by $\lambda = \frac{h}{p}$ ...(ii)

where, p is being momentum of photon.

From Eqs. (i) and (ii), we get

$$E = \frac{hc}{\frac{h}{p}} = pc \Rightarrow p = \frac{E}{c}$$

Given, $E = 1\text{MeV} = 1 \times 10^6 \times 1.6 \times 10^{-19}$ J,

$c = 3 \times 10^8 \text{ ms}^{-1}$

Hence, after putting numerical values, we obtain

$$p = \frac{1 \times 10^6 \times 1.6 \times 10^{-19}}{3 \times 10^8}$$
$$= 5 \times 10^{-22} \text{ kg} - \text{ms}^{-1}$$

6 **(b)**

Suppose, mass of electron = m_e

Mass of photon = m_{ph}

Velocity of electron = v_e

and velocity of photon = v_{ph}

Given, velocity of electron, $v_e = \frac{c}{100}$

Thus, for electron, de-Broglie wavelength,

$$\lambda_e = \frac{h}{m_e v_e} = \frac{h}{m_e(c/100)} = \frac{100h}{m_e c} \quad ...(i)$$

Kinetic energy, $E_\theta = \frac{1}{2} m_e v_\theta^2$

$\Rightarrow \quad m_e v_e = \sqrt{2E_e m_e}$

As, de-Broglie wavelength,

$$\lambda_e = \frac{h}{m_e v_e} = \frac{h}{\sqrt{2 m_e E_\theta}}$$

$\Rightarrow E_\theta = \frac{h^2}{2\lambda_e^2 m_e}$ ...(ii)

Now, for photon with wavelength λ_{ph} energy,

$E_{ph} = \frac{hc}{\lambda_{ph}} = \frac{hc}{2\lambda_e}$ ...(iii)

$[\because \lambda_{ph} = 2\lambda_e \text{ (given)}]$

On dividing Eq. (iii) by Eq. (ii), we get

$$\therefore \frac{E_{ph}}{E_e} = \frac{hc}{2\lambda_\theta} \times \frac{2\lambda_e^2 m_e}{h^2}$$

$= \frac{\lambda_\theta m_e c}{h} = \frac{100h}{m_e c} \times \frac{m_e c}{h} = 100$ [using Eq. (i)]

So, $\frac{E_\theta}{E_{ph}} = \frac{1}{100} = 10^{-2}$

For electron, $p_e = m_e v_e = m_e \times (c/100)$

So, $\frac{p_\theta}{m_\theta c} = \frac{1}{100} = 10^{-2}$

7 **(d)**
From graph, $v = 10^{15}$ Hz

$K_{max} = 3eV = 3 \times 1.6 \times 10^{-19}$ J

As, $K_{max} = hv - hv_0$

$$\Rightarrow v_0 = v - \frac{K_{max}}{h}$$

$$= 10^{15} - \frac{3 \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}}$$

$$= (10 - 7.3) \times 10^{14} = 2.7 \times 10^{14} \text{ Hz}$$

8 **(b)**
The de-Broglie wavelength is given by

$$\lambda = \frac{h}{p} \Rightarrow p\lambda = h \Rightarrow p \propto \frac{1}{\lambda}$$

This equation is in the form of $yx = c$, which is the equation of a rectangular hyperbola. Hence, the graph given in option (b) is the correct one.

9 **(a)**
de-Broglie wavelength is $\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mE}}$

But $E = eV$ and $\lambda = \frac{h}{\sqrt{2meV}} \Rightarrow V = \frac{h^2}{2me\lambda^2}$

$$= \frac{(6.62 \times 10^{-34})^2}{2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19} \times (0.50 \times 10^{-10})^2}$$

$\Rightarrow V = 601.98 \text{ V} \approx 602 \text{ V}$

10 **(b)**
Work function for wavelength of 4100 A.

$$\phi = \frac{hc}{\lambda} = \frac{6.62 \times 10^{34} \times 3 \times 10^8}{4100 \times 10^{-10}}$$

$$= 4.8 \times 10^{-19} \text{ J} = \frac{4.8 \times 10^{19}}{1.0 \times 10^{19}} \text{eV} = 3\text{eV}$$

Now, we have $\phi_A = 1.92$eV, $\phi_B = 2.0$eV, $\phi_s = 5$eV

Since, $\phi_A < \phi$ and $\phi_B < 0$, hence A and B will en it photoelectric.

11 **(c)**
Given for a metal, wavelength of light used $= \lambda$
Stopping potential $= V$
If λ_0 be the threshold wavelength, then maximum kinetic energy of emitted electrons,

$K_{max} = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right) = eV$
...(i)

Again, wavelength of light used, $\lambda' = 2\lambda$ Stopping potential, $V' = \frac{V}{3}$

Then, $K_{max} = hc\left(\frac{1}{\lambda'} - \frac{1}{\lambda_0}\right) \Rightarrow eV' = hc\left(\frac{1}{2\lambda} - \frac{1}{\lambda_0}\right)$

$\Rightarrow \frac{eV}{3} = hc\left(\frac{1}{2\lambda} - \frac{1}{\lambda_0}\right)$
...(ii)

On dividing Eq. (i) by Eq. (ii), we get

$$\frac{eV}{\frac{eV}{3}} = \frac{hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)}{hc\left(\frac{1}{2\lambda} - \frac{1}{\lambda_0}\right)}$$

$$\Rightarrow 3\left(\frac{1}{2\lambda} - \frac{1}{\lambda_0}\right) = \frac{1}{\lambda} - \frac{1}{\lambda_0}$$

$\Rightarrow \lambda_0 = 4\lambda$

So, threshold wavelength is 4 times of wavelength of light.

12 **(a)**

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Here, $\frac{1}{2}mv_1^2 = 3\phi - \phi = 2\phi$ ($\because$ KE $= hv - \phi$)

and $\frac{1}{2}mv_2^2 = 9\phi - \phi = 8\phi$

$\therefore\ v_2^2 = 4v_1^2 \Rightarrow v_2 = 2v_1 = 2 \times 6 \times 10^4$

$= 12 \times 10^6\ ms^{-1}$

13 **(a)**
According to photoelectric equation,

$$\frac{hc}{\lambda} = \phi + E$$

If E is constant, then

$$\frac{1}{\lambda} \propto \phi$$

If we decrease the wavelength λ, then stopping potential ϕ will increase such that $\frac{hc}{\lambda} - \phi =$ constant.

14 **(d)**
$eV_0 = \frac{hc}{\lambda_0} - \phi_0$ and $eV'' = \frac{hc}{2\lambda_0} - \phi_0$

Subtracting them, we have

$$e(V_0 - V') = \frac{hc}{\lambda_0}\left(1 - \frac{1}{2}\right) = \frac{hc}{2\lambda_0} \Rightarrow V' = V_0 - \frac{hc}{2e\lambda_0}$$

15 **(d)**
from p. photoelectric equation o: Einstein,

$$eV_0 + \phi = \frac{hc}{\lambda}$$

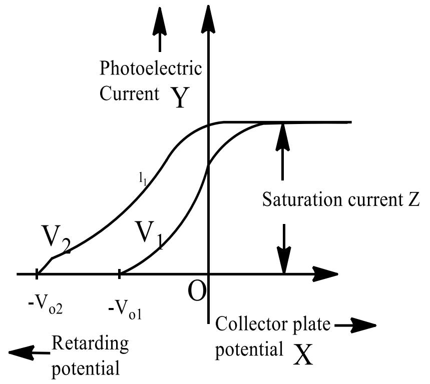
and $\quad eV_0' + \phi = \frac{hc}{\lambda'}$

$$\because \quad eV_0 + \theta = \frac{\lambda}{\lambda'} = \frac{100}{200} = \frac{1}{2}$$

$$\Rightarrow\ 2\epsilon_0 + \phi_0 + 2\phi = eV_0 + \phi$$

$$\Rightarrow \quad eV_0' = \frac{eV_0 - \phi}{2} = \frac{7.7 - 4.7}{2} = 1.5\ V$$

16 **(c)**
For incident radiation at same intensity and at varying frequencies, the given graph represents the variation of photocurrent with collector plate potential. This can be as shown in graph below.



Thus, X → collector plate potential,
Y → photocurrent and Z → saturation current.

17 **(a)**
$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2qVm}}$

or $\lambda \propto \frac{1}{\sqrt{qm}}$

$$\because\ \frac{\lambda_p}{\lambda_\alpha} = \sqrt{\frac{q_\alpha}{q_p} \cdot \frac{m_\alpha}{m_p}} = \sqrt{\frac{(2)(4)}{(1)(1)}} = 2.828$$

The nearest integer is 3 .

18 **(b)**
We know that, energy of photon, $E = hv$

But we also know that,

$E = \frac{1}{2}mv^2 \Rightarrow 2E = \frac{p^2}{m}$ (for proton)

$\Rightarrow\ p = \sqrt{2mE}$ ($\therefore$ p=mv)

According to the question, $\lambda_1 = \frac{h}{p}$ ...(ii)

And $\lambda_2 = \frac{hc}{E}$ ...(iii)

On dividing Eq. (ii) by Eq. (iii), we get

$$\frac{\lambda_1}{\lambda_2} = \frac{h/p}{hc/E} = \frac{E}{pc}$$

$$\Rightarrow \quad \frac{\lambda_1}{\lambda_2} = \frac{E}{\sqrt{2mE} \cdot c} = \frac{\sqrt{E}}{\sqrt{2m} \cdot c}$$

So, $\frac{\lambda_1}{\lambda_2} = \frac{\sqrt{E}}{\sqrt{2m} \cdot c} \Rightarrow \frac{\lambda_1}{\lambda_2} \propto \sqrt{E}$ or $E^{1/2}$

$\Rightarrow \lambda_1 : \lambda_2 = E^{1/2}$

19 **(b)**
Given, energy of photon $= hv$, work function $= W_0$ and maximum kinetic energy $= K$

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So, from the Einstein's photoelectric equation,

$E = K + W_0 \Rightarrow hv = K + W_0$

$\Rightarrow K = hv - W_0$ ...(i)

If frequency of the radiation is doubled, then Einstein's photoelectric equation changed as

$K' = h(2v) - W_0$ ...(ii)

By subtracting Eq. (i) from Eq. (ii), we get

$K' - K = h(2v) - hv - W_0 + W_0$

$\Rightarrow K' = K + hv$

20 **(a)**
de-Broglie wavelength, $\lambda = \frac{h}{p} = \frac{h}{mv}$

$$\Rightarrow \quad p = \frac{h}{\lambda}$$

where, h is a constant.

So,$p \propto \frac{1}{\lambda}$

So, for two given particles A_1 and A_2, we can write

$$\frac{p_1}{p_2} = \frac{\lambda_2}{\lambda_1}$$

But $\lambda_1 = \lambda_2 = \lambda$

Then, $\frac{p_1}{p_2} = \frac{\lambda}{\lambda} = 1 \Rightarrow p_1 = p_2$ ...(i)

Thus, their momenta is Same.

Also, $E = \frac{1}{2}mv^2 = \frac{1}{2}\frac{mv^2 \times m}{m}$

$= \frac{1}{2}\frac{m^2v^2}{m} = \frac{1}{2}\frac{p^2}{m}$ $(\because p = mv)$

Here, p is constant.

$\Rightarrow E \propto \frac{1}{m}$

$\because \frac{E_1}{E_2} = \frac{m_2}{m_1} < 1$ $(\because m_1 > m_2)$

$\Rightarrow E_1 < E_2$

Thus, energy of particle A_1 is less than energy of particle A_2.

21 **(c)**

The work function for aluminium,

$\phi_0 = 4.125\text{eV}$

$= 4.125 \times 1.6 \times 10^{-19} = 6.6 \times 10^{-19}$ J

The relation for work function is given by

$\phi_0 = \frac{hc}{\lambda}$ (where, λ is the cut-off wavelength)

$$6.6 \times 10^{-19} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{\lambda}$$

$$\Rightarrow \quad \lambda = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{6.6 \times 10^{-19}}$$

$$= \frac{19.8 \times 10^{-26}}{6.6 \times 10^{-19}} = 3 \times 10^{-7}\ \text{m}$$

$$= 300 \times 10^{-9}\ \text{m} = 300\ \text{nm}$$

22 **(b)**
de-Broglie wavelength associated with a moving particle can be given as

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2m((KE)}}$$

At thermal equilibrium, temperature of neutron and heavy water will be same.
This common temperature is given as T.
As we know, kinetic energy of the neutron (KE) = $\frac{3}{2}kT$

$\therefore$ de-Broglie wavelength of the neutron,

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2m(KE)}}$$

$$= \frac{h}{\sqrt{2m \times \frac{3}{2}kT}} = \frac{h}{\sqrt{3mkT}}$$

23 **(b)**
Given, $E/c = 3.3 \times 10^{-13}\ \text{kg} - \text{ms}^{-1}$

So, $E = 3.3 \times 10^{-13} \times c$

$= 3.3 \times 10^{-13} \times 3 \times 10^8 = 9.9 \times 10^{-5}$ J

24 **(b)**
From photoelectric equation,

$hv = \phi + eV_0$ (where, ϕ = work function)

So, $\frac{hc}{\lambda} = \phi + 3eV_0$ ...(i)

Also, $\frac{hc}{2\lambda} = \phi + eV_0$

$\Rightarrow \frac{hc}{\lambda} = 2\phi + 2eV_0$ ...(ii)

Subtracting Eq. (i) from Eq. (ii), we get

$0 = \phi - eV_0 \Rightarrow \phi = eV_0$

From Eq. (i), we get

$\frac{hc}{\lambda} = eV_0 + 3eV_0 = 4eV_0$

The threshold wavelength is given by

$\lambda_{th} = \frac{hc}{\phi} = \frac{4eV_0\lambda}{eV_0} = 4\lambda$

25 **(a)**
According to Einstein's theory of photoelectric effect, a single incident photon ejects a single electron. Therefore, when intensity increases, the number of incident photons increases, so number of ejected electrons increases,

hence photocurrent increases.
Now, maximum energy of electron $= \frac{1}{2}mv_{max}^2$ and $\frac{1}{2}mv_{max}^2 = eV_0$, where V_0 is stopping potential.

Thus, the maximum kinetic energy of the electrons does not depend upon the intensity of the incident rays, because the stopping potential is not affected by the increase of the intensity of rays.

26 **(a)**
At stopping potential, the maximum velocity of emitted photoelectron from metal surface is given by $K_{max} = \frac{1}{2}mv^2 = ev_0$

$\therefore$ Stopping potential, $V_0 = \frac{mv^2}{2e} = \frac{v^2}{2\left(\frac{e}{m}\right)}$

27 **(a)**
Wavelength of electron,

$\lambda_e = \frac{h}{\sqrt{2mE}}$ and photon, $\lambda_p = \frac{hc}{E}$

$\Rightarrow \lambda_\theta^2 = \frac{h^2}{2mE}$ and $E = \frac{hc}{\lambda_p}$

$\therefore \lambda_e^2 = \frac{h^2}{2m \cdot \frac{hc}{\lambda_p}}$

$\Rightarrow \lambda_e^2 = \frac{h^2}{2mhc}\lambda_p \Rightarrow \lambda_e^2 \propto \lambda_p$ or $\lambda_p \propto \lambda_\theta^2$

28 **(b)**
Given, the linear momentum of a particle (p)

$= 2.2 \times 10^4$ kg − ms^{-1} and $h = 6.6 \times 10^{-34}$ J − s

The de-Broglie wavelength of particle,

$\lambda = \frac{h}{p} = \frac{6.6\times10^{-34}}{2.2\times10^4}$

or $\lambda = 3 \times 10^{-38}$ m $= 3 \times 10^{-29}$ nm

29 **(a)**
Work function, $\phi_0 = hv_0$

where, v_0 = threshold frequency.

So, $\phi_0 \propto v_0$, hence Pt > Al > K.

30 **(b)**
We know that,

$\lambda = \frac{h}{\sqrt{2m(KE)}}$

On taking square of both sides, we get

$\lambda^2 = \frac{h^2}{2m(KE)}$

$\Rightarrow KE = \frac{h^2}{2m\lambda^2}$

31 **(c)**
$eV_0 = hf - \phi_0$, where V_0 = stopping potential

and f = frequency.
When frequency is doubled,

$eV_0' = 2hf - \phi_0 = 2(eV_0 + \phi_0) - \phi_0 = 2eV_0 + \phi_0$

$\therefore V_0' = 2V_0 + \frac{\phi_0}{e}$

So, stopping potential is more than double.

32 **(d)**
According to question, using Einstein's

photoelectric equation, $\frac{hc}{\lambda} - \phi = eV$
In first case, for λ stopping potential is V,
i.e. equation becomes

$$\frac{hc}{\lambda} - \phi = eV \quad ...(i)$$

Similarly, in second case, for 3λ stopping potential is $\frac{V}{6}$,

i.e. equation becomes

$$\frac{hc}{3\lambda} - \phi = \frac{eV}{6}$$

$$\Rightarrow \frac{2hc}{\lambda} - 6\phi = eV \quad ...(ii)$$

Subtracting Eq. (i) from Eq. (ii), we get

$$\left(\frac{2hc}{\lambda} - 6\phi\right) - \left(\frac{hc}{\lambda} - \phi\right) = eV - eV$$

$$\Rightarrow \frac{hc}{\lambda} = 5\phi$$

$$\Rightarrow \phi = \frac{hc}{\lambda_0} = \frac{hc}{5\lambda}$$

Thus, $\lambda_0 = 5\lambda$

33 **(a)**
Diffraction exhibits wave nature of light and photoelectric effect exhibits quantum nature of light. Hence, diffraction and photoelectric effect exhibit dual nature of light.

34 **(b)**

$$\therefore \lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE}} \propto \frac{1}{\sqrt{E}}$$

35 **(c)**
In photoelectric emission,
kinetic energy of emitted electron
= energy of incident photon - work function

$$\Rightarrow \frac{1}{2}mv^2 = E - W$$

$$\text{or } v = \sqrt{\frac{2(E-W)}{m}}$$

$$\because \frac{v_1}{v_2} = \sqrt{\frac{2(E_1 - W)}{m}} \times \sqrt{\frac{m}{2(E_2 - W)}} = \sqrt{\frac{E_1 - W}{E_2 - W}}$$

$$= \sqrt{\frac{3W-W}{5W-W}} = \sqrt{\frac{2}{4}} = \frac{1}{\sqrt{2}} \text{ or } 1:\sqrt{2}$$

36 **(d)**
As, maximum kinetic energy,

$$K_{max} = E - \phi_0 \quad ...(i)$$

Given, energy of photon that strikes metal A,

$$E_A = 4.25\text{eV}$$

∴ Maximum kinetic energy for metal A,

$$T_A = 4.25 - (\phi_0)_A \quad ...(ii)$$

[using Eq. (i)]

Energy of photon, $E_B = 4.70\text{eV}$
∴ Maximum kinetic energy for metal B,
$T_B = 4.70 - (\phi_0)_B \quad ...(iii)$

[using Eq. (ii)]

it is given that,

$$T_B = T_A - 1.5$$

So, Eq. (iii) can be given as

$$T_A - 1.5 = 4.70 - (\phi_0)_B$$

Substituting the value of T_A from Eq. (ii) in the above equation, we get

$$4.25 - (\phi_0)_A - 1.5 = 4.70 - (\phi_0)_B$$

$$(\phi_0)_B - (\phi_0)_A = (4.70 - 2.75)$$

$$(\phi_0)_B - (\phi_0)_A = 1.95\text{eV} \quad ...(iv)$$

As, de-Broglie wavelength,

$$\lambda = \frac{h}{\sqrt{2meV}} \text{ or } \lambda = \frac{h}{\sqrt{2mK}}$$

$$\Rightarrow \lambda \propto \frac{1}{\sqrt{K}}$$

$$\therefore \frac{\lambda_B}{\lambda_A} = \sqrt{\frac{K_A}{K_B}} = \sqrt{\frac{T_A}{T_B}} = \sqrt{\frac{T_A}{T_A - 1.5}}$$

Given, $\lambda_B = 2\lambda_A$

$$\Rightarrow 2 = \sqrt{\frac{T_A}{T_A - 1.5}} \Rightarrow T_A = 2\text{eV}$$

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and $T_B = T_A - 1.5 = (2 - 1.5)eV = 0.5eV$

$T_B = 0.5eV$

Also, from Eq. (ii), we get

$$2 = 4.25 - (\phi_0)_A$$

$\Rightarrow (\phi_0)_A = 2.25eV$

Now, from Eq. (iv), we get

$(\phi_0)_B - 2.25 = 1.95 \Rightarrow (\phi_0)_B = 4.20eV$

37 **(c)**
Energy of photoelectron,

$$E = \frac{hc}{\lambda} - \phi \Rightarrow \frac{hc}{\lambda} = E + \phi \qquad ....(i)$$

where, ϕ is the work function for the metal surface (constant).

$$2E = \frac{hc}{\lambda'} - \phi \Rightarrow \frac{hc}{\lambda'} = 2E + \phi \qquad ...(ii)$$

On dividing Eq. (i) by Eq. (ii), we get

$$\frac{\lambda'}{\lambda} = \frac{E+\phi}{2E+\phi} = \frac{(E+\phi)}{2\left(E+\frac{\phi}{2}\right)}$$

$\therefore \frac{\lambda'}{\lambda} > \frac{1}{2}$ or $\lambda' > \frac{\lambda}{2}$

$\therefore \lambda > \lambda' > \frac{\lambda}{2}$

38 **(c)**
Kinetic energy of photoelectrons $= \frac{1}{2}mv^2 = eV$

$\frac{1}{2} \times 9.1 \times 10^{-31} \times v^2 = 1.6 \times 10^{-19} \times 182$

$\Rightarrow v^2 = \frac{1.6 \times 10^{-19} \times 182 \times 2}{9.1 \times 10^{-31}}$

$\Rightarrow v^2 = 64 \times 10^{12}\ ms^{-1}$

$\Rightarrow \ v = 8 \times 10^6\ ms^{-1}$

39 **(b)**
The graph between stopping potential and frequency is a straight line, so stopping potential and hence, maximum kinetic energy of photoelectrons for both the metals depend linearly on the frequency.

40 **(a)**
Maximum KE $= hv - \phi_0$

$= 6.63 \times 10^{-34} \times 8 \times 10^{14} - 3.2 \times 10^{-19}$

$= 2.1 \times 10^{-19}$ J

41 **(a)**
de-Broglie wavelength of an electron is given by

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

where, h is Planck's constant.
Given,

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

$E = 10keV = 10 \times 10^3 \times 1.6 \times 10^{-19}$ J

$h = 6.6 \times 10^{-34}$ J − s

Substituting the above values, we get

$$\lambda = \frac{6.6 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 10 \times 10^3 \times 1.6 \times 10^{-19}}}$$

$= 1.22 \times 10^{-11} \approx 0.12Å$

42 **(a)**
Wavelength of photon will be greater than that of electron because mass of photon is less than that of electron, i.e $\lambda_p > \lambda_\theta$.

43 **(b)**
The work function of a surface is

$\phi = hv_0$
where, h = Planck's constant

and v_0 = threshold frequency.
From graph, it is clear that

$(v_0)_P < (v_0)_Q$

$\therefore \phi_P < \phi_Q$

44 **(b)**
Maximum KE is given by

$K_{max} = hv - \phi_0$

$$= \frac{6.62 \times 10^{-34} \times 6 \times 10^{14}}{1.6 \times 10^{-19}} - 2.14$$

$= 2.485 - 2.140$

$= 0.345eV$

Minimum kinetic energy,

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$K_{min} = 0$

Stopping potential, $V_0 = \frac{K_{max}}{e} = \frac{0.345eV}{\theta}$ or

$V_0 = 0.345\ V = 345mV$
Maximum speed of emitted electrons,

$$K_{max} = \frac{1}{2}mv^2\ m \quad \text{or} \quad v_{max} = \sqrt{\frac{2K_{max}}{m}}$$

$$= \sqrt{0.121 \times 10^{12}}$$

$$= 3.478 \times 10^5\ ms^{-1}$$

$$= 348kms^{-1}$$

Hence, $A \to 3, B \to 4, C \to 2, D \to 1$.

45 **(c)**
Let E_1 and E_2 be the KE of photoelectron for incident light of frequency v and 2v, respectively.

Then, $hv = E_1 + \phi_0$

and $h \times 2v = E_2 + \phi$

So, $2(E_1 + \phi_0) = E_2 + \phi$

or $E_2 = 2E_1 + \phi_0$

It means the KE of photoelectron becomes more than double.

46 **(b)**

$$\text{As}, \Delta E = \frac{hc}{e\lambda_1} - \frac{hc}{e\lambda_2} = \frac{hc(\lambda_2 - \lambda_1)}{e\lambda_1\lambda_2}\ (\text{in eV})$$

$$= \frac{6.62\times10^{-34}\times3\times10^8\times(5000-2500)\times10^{-10}}{1.6\times10^{-19}\times2500\times5000\times10^{-20}}$$

$$= 2.47eV$$

47 **(d)**

Momentum, $p = mv$ and $v = \sqrt{\frac{2qV}{m}}$

$$\Rightarrow p = \sqrt{2qmV} \propto \sqrt{qm}$$

$$\because \frac{p_\theta}{p_\alpha} = \sqrt{\frac{em_\theta}{2em_\alpha}} = \sqrt{\frac{m_\theta}{2m_\alpha}}$$

48 **(d)**

$$K_p = E_p - \phi_p = \frac{1240}{550} - 2.0 = 0.2545eV$$

$$K_q = E_q - \phi_q = \frac{1240}{450} - 2.5 = 0.255eV$$

$$K_r = E_r - \phi_r = \frac{1240}{350} - 3.0 = 0.543eV$$

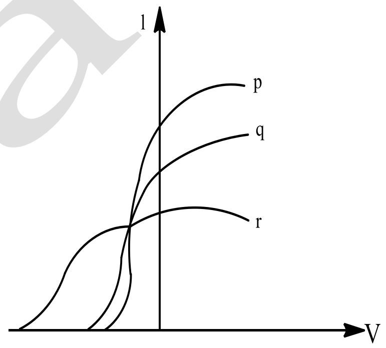
In the above equation, K represents maximum kinetic energy of photoelectrons and E represents the energy of incident light.

From the above values, we can see that stopping potential,

$$|V_r| > |V_q| > |V_p|$$

Further, their intensities are equal but energy of individual photon of r is maximum. Hence, number of photons incident (per unit area per unit time) of r can be assumed to be least. Hence, saturation current of r should be minimum.

Keeping these points in mind no option seems to be correct. The correct graph is shown below.



49 **(a)**
For a particular frequency of incident radiation, the minimum negative (retarding) potential V_0 given to the collector plate for which the photoelectric current stops or becomes zero is called the cut-off or stopping potential.
From given the graph,
The value of stopping potential, $V_0 = -0.54$ V.

50 **(c)**
From the graph, stopping potential, $V_0 = -3.2$ V

For photoelectric effect, $eV_0 = hv$

$$\Rightarrow v = \frac{eV_0}{h}$$

$$v = \frac{1.6\times10^{-19}\times3.2}{6.6\times10^{-34}}$$

$$= 0.775 \times 10^{15}\ \text{Hz or s}^{-1}$$

51 **(d)**

de-Broglie wavelength for an electron will be given as

$\lambda_\theta = \frac{h}{p}$ ....(i)

where, h = Planck's constant

and p = linear momentum of electron.

As, kinetic energy of electron, $E = \frac{p^2}{2m}$

$\Rightarrow p = \sqrt{2mE}$ ...(ii)

From Eqs. (i) and (ii), we get

$\lambda_e = \frac{h}{\sqrt{2mE}}$ ...(iii)

Energy of a photon can be given as

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

where, λ_p = de-Broglie's wavelength of photon.

$\Rightarrow \lambda_p = \frac{hc}{E}$ ...(iv)

Now, on dividing Eq. (iii) by Eq. (iv), we get

$= \frac{\lambda_e}{\lambda_p} = \frac{h}{\sqrt{2mE}} \cdot \frac{E}{hc}$

$\Rightarrow \frac{\lambda_e}{\lambda_p} = \frac{1}{c} \cdot \sqrt{\frac{E}{2m}} = \frac{1}{c}\left(\frac{E}{2m}\right)^{\frac{1}{2}}$

52 **(a)**

The energy of photon is given as

$E_p = \frac{hc}{\lambda_p}$

$\therefore \lambda_p = \frac{hc}{E_p}$ ...(i)

Energy of a moving electron is given as

$E_\theta = mc^2 = pc$

$\Rightarrow p = \frac{E_p}{c}$

$\therefore \lambda_e = \frac{h}{p} = \frac{hc}{E_\theta}$ ....(ii)

Given, $E_p = E_\theta$.
Therefore, from Eqs. (i) and (ii), we get

$\lambda_p \propto \lambda_e$

53 **(c)**

The maximum kinetic energy of emitted photoelectron is

$K_{max} = eV_s$

where, V_s = stopping potential.

$\Rightarrow V_s = \frac{K_{max}}{e} = \frac{3.2 \times 10^{-19}}{1.6 \times 10^{-19}} = 2\text{ V}$

Also, the work function of a metal is

$\phi = \frac{1242}{\lambda_0(\text{ nm})}\text{eV}$

$\Rightarrow \lambda_0 = \frac{1242 \times 1.6 \times 10^{-19}}{\phi}\text{nm}$

$\Rightarrow = \frac{1242 \times 1.6 \times 10^{-19} \times 10^{-9}}{6.63 \times 10^{-19}}\text{ m}$

$= 299.7 \times 10^{-9} = 2997 \times 10^{-10}\text{ m}$

$= 2997\text{Å} \simeq 3000\text{Å}$

54 **(d)**

The maximum kinetic energy of photoelectrons is given by

$(KE)_{max} = h(v - v_0)$ ...(i)

where, h = Planck's constant, v = frequency of radiation and v_0 = threshold frequency.
It can be seen from Eq. (i), that the maximum KE of emitted photoelectron is proportional to the frequency of radiation and is independent of the intensity of radiation, so it remains unchanged.

55 **(b)**

Photoemission is possible only with frequency greater than threshold frequency. It will not depend on the intensity of light.

56 **(d)**

As the distance of source from the emitter increases, intensity of radiation decreases.

$\cdots$ Intensity $\left(\propto \frac{1}{[\text{ Distance (d)}]^2}\right.$ and since,

Photoelectric current (i) $\propto$ I Intensity (I) $\propto \frac{1}{d^2}$
Thus, we variation of i with distance d is correctly deptcted by the curve d in the given figure.

57 **(b)**

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According to Bohr's quantization of angular momentum,

$mvr = \frac{nh}{2\pi}$ or $\frac{h}{mv} = \frac{2\pi r}{n}$ ...(i)

de-Broglie wavelength,

$\lambda = \frac{h}{mv}$ ....(ii)

From Eqs. (i) and (ii), we get

Wavelength, $\lambda = \frac{2\pi r}{n} = \frac{2\times\pi\times0.53Å}{1} = 3.33Å$

58 **(c)**
We know that, $p = \frac{h}{\lambda}$ or $mv = \frac{h}{\lambda}$
$\therefore$ As both the particle and electron have same wavelength, therefore their momentum will be equal, i.e.

$m_p v_p = m_e v_\theta$

$\Rightarrow v_p = \frac{m_\theta v_\theta}{m_p} = \frac{9.1\times10^{-31}\times3\times10^{6}}{10^{-6}}$

$\Rightarrow v_p = 2.7\times10^{-18}\ ms^{-1}$

59 **(c)**
As, $\frac{1}{2}mv_{max}^2 = hv \Rightarrow v_{max}^2 = \frac{2hv}{m}$

$\therefore v_{max} = \sqrt{\frac{2hv}{m}}$

60 **(b)**
Energy of photon, $E = \frac{12375}{\lambda(\text{ in }Å)}eV$

For red light, the wavelength is maximum,

$\because \lambda_R = 7900Å$

$\because E = \frac{12375}{7900}eV = 1.56eV \simeq 1.6eV$

61 **(c)**
By the concept of minimum (or threshold) frequency needed for photoelectric emission,
$\frac{1}{2}mv^2 = h(v - v_0)$

$v \geq V_o$

62 **(b)**
Momentum of incident light per second,

$p_1 = \frac{E}{c} = \frac{60}{3\times10^8} = 2\times10^{-7}\ kg - ms^{-1}$

Momentum of reflected light per second,

$p_2 = \frac{60}{100}\times\frac{E}{c}$

$= \frac{60}{100}\times2\times10^{-7}$

$= 1.2\times10^{-7}\ kg - ms^{-1}$

$\therefore$ Force on the surface = Change in momentum per second

$= p_2 - (-p_1) = p_2 + p_1$

$= (2 + 1.2)\times10^{-7}$

$= 3.2\times10^{-7}\ N$

63 **(a)**
Power emitted, $P = 2\times10^{-3}\ W$

Energy of photon, $E = hv = 6.6\times10^{-34}\times6\times10^{14}\ J$

Number of photons emitted per second,

$n = \frac{P}{E} = \frac{2\times10^{-3}}{6.6\times10^{-34}\times6\times10^{14}}$

$= 5\times10^{15}$

64 **(b)**
According to Einstein's equation,

$KE_{max} = hv_0 - \phi_0$

where, KE_{max} = maximum kinetic energy and ϕ_0 = work function.
Initially, $hv = 0.4 + \phi_0$ ...(i)

When the frequency of incident radiation is increased by 30%, then

$1.3hv = 0.9 + \phi_0$ ...(ii)

Solving Eqs. (i) and (ii), we get

$0.3\phi_0 = 0.9 - 1.3(0.4)$

$\therefore \phi_0 = \frac{0.38}{0.3} = 1.267eV$

65 **(c)**

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$$\because \frac{\lambda_\theta}{\lambda_p} = \frac{\frac{h}{m_\theta v}}{\frac{h}{m_p v}} = \frac{m_p}{m_\theta} = \frac{1.67 \times 10^{-27}}{9.1 \times 10^{-31}}$$

$$= 0.1836 \times 10^4 = 1836$$

66 **(b)**

As, maximum KE $= \frac{hc}{\lambda} - \phi_0$

$$= \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{4000 \times 10^{-10}} \times \frac{1}{1.6 \times 10^{-19}} - 2$$

$= 1.1\text{eV}$

67 **(b)**

As, $\frac{1}{2}mv_1^2 = 2hv_0 - hv_0 = hv_0$

and $\frac{1}{2}mv_2^2 = 5hv_0 - hv_0 = 4hv_0$

So, $\frac{1}{2}mv_2^2 = 4 \times \frac{1}{2}mv_1^2$

or $v_2 = 2v_1 = 2 \times 4 \times 10^6 = 8 \times 10^6\ \text{ms}^{-1}$

68 **(c)**

In the given condition, photocurrent is zero when the stopping potential is sufficient to repel even the most energetic photoelectrons with the maximum kinetic energy…

thus, at point P(as shown in the given figure), it can be seen clearly that the electron must have been repelled, so maximum kinetic energy

$K=eV_o$.

69 **(a)**

Energy radiated as visible light

$$= \frac{5}{100} \times 100 = 5\text{Js}^{-1}$$

Let n be the number of photons emitted per second,

then $nhv = E = 5$ $\quad (\because v = c/\lambda)$

$$\therefore\ n = \frac{5\lambda}{hc} = \frac{5 \times 5.6 \times 10^{-7}}{(6.62 \times 10^{-34})(3 \times 10^8)}$$

$$= 1.4 \times 10^{19}$$

70 **(c)**

As Source is moved away, intensity decreases but frequency remains same.

∴ No effect on the stopping potential.

71 **(b)**

Above the threshold frequency, the maximum kinetic energy of the emitted photoelectrons depends on the frequency of the incident light, but is independent of the intensity of the incident light so long as the letter is not too high.

72 **(a)**

Here, initial velocity, $u = 0$

Acceleration of the electron in constant electric field E,

$a = \frac{eE}{m}$, final velocity, $v = ?$, time, $t = t$

Using kinematic equation of motion,

$v = u + at = 0 + \frac{eE}{m}t \quad (\because u = 0)$

$\Rightarrow\ v = \frac{eEt}{m}$

de-Broglie wavelength, $\lambda = \frac{h}{mv} = \frac{h}{m(eEt/m)} = \frac{h}{eEt}$

Rate of change of de-Broglie wavelength,

$$\frac{d\lambda}{dt} = \frac{h}{eE}\left(-\frac{1}{t^2}\right) = \frac{-h}{eEt^2}$$

73 **(a)**

Momentum of striking electrons, $p = \frac{h}{\lambda}$

∴ Kinetic energy of striking electrons,

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

This is also maximum energy of X-ray photons.

Therefore, $\frac{hc}{\lambda_0} = \frac{h^2}{2m\lambda^2}$ or $\lambda_0 = \frac{2m\lambda^2 c}{h}$

74 **(c)**

$K_{max} = hf_1 - \phi_0 = hf_1 - hf_0 = h(f_1 - f_0)$

75 **(c)**

As, $\phi_0 = \frac{hc}{e\lambda_0}$ (in eV)

$$= \frac{6.62 \times 10^{-34} \times 3 \times 10^8}{1.6 \times 10^{-19} \times 5420 \times 10^{-10}} = 2.29\text{eV}$$

76 **(c)**

Energy incident over 1 $\text{cm}^2 = 1.0 \times 10^{-4}$ J Energy required to produce photoelectrons

$= 1.0 \times 10^{-4} \times 10^{-2}$

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$= 10^{-6}$ J

As number of photoelectrons ejected = number of photons which can produce photoelectrons = energy required for producing electron/energy of photon

$$= \frac{10^{-6}}{\frac{hc}{\lambda}} = \frac{10^{-6} \times 300 \times 10^{-9}}{6.6 \times 10^{-34} \times 3 \times 10^{8}}$$

$= 1.51 \times 10^{12}\ s^{-1}$

77 **(b)**
In photoelectric effect, the maximum kinetic energy possessed by the particle,

$KE_{max} = hv - \phi$

$\frac{1}{2}mv^2 = \frac{hc}{\lambda} - \phi \qquad \left(\because v = \frac{c}{\lambda}\right)$

$$v^2 = \frac{2(hc - \phi\lambda)}{\lambda m}$$

$$v = \left[\frac{2(hc - \lambda\phi)}{m\lambda}\right]^{1/2}$$

78 **(a)**
According to Einstein's theory of photoelectric effect, we have energy of incidence photon

= KE of photoelectron + work function
i.e. $hv = \frac{1}{2}mv_{max}^2 + \phi_0$
Given, $E_1 = 1eV$

$E_2 = 2.5eV, \phi_0 = 0.5eV$

We know that, $E = \phi_0 + K_{max}$
In the first condition, $1 = 0.5 + K_1$
$K_1 = 0.5$ ...(i)

Similarly, $2.5 = 0.5 + K_2$

$K_2 = 2$ ...(ii)

We know that, $\frac{v_1}{v_2} = \sqrt{\frac{K_1}{K_2}}$
From Eqs. (i) and (ii), we get

$$\frac{v_1}{v_2} = \sqrt{\frac{1}{4}} \Rightarrow \frac{v_1}{v_2} = \frac{1}{2}$$

79 **(d)**
Using the relation, $E = hv = 6.63 \times 10^{-34} \times 10^{18}$ J

$$= \frac{6.63 \times 10^{-16}}{1.6 \times 10^{-19}} eV$$

$$= 4.14 \times 10^{3} eV$$

80 **(b)**
As, $\phi_0 = \frac{hc}{e\lambda_0}$ (in eV)

$$= \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{1.6 \times 10^{-19} \times 6600 \times 10^{-10}}$$

$= 1.87eV$

81 **(c)**
de-Broglie wavelength of an electron is given by

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

or $\lambda \propto \frac{1}{\sqrt{E}}$
$\because \frac{\lambda'}{\lambda} = \frac{1}{\sqrt{3E}}\frac{\sqrt{E}}{1} = \frac{1}{\sqrt{3}}$ or $\lambda' = \frac{\lambda}{\sqrt{3}}$
Hence, de-Broglie wavelength will change by a factor $\frac{1}{\sqrt{3}}$.

82 **(b)**
$E - \phi_0 = \frac{1}{2}mv^2$

Case I $\quad 2\phi_0 - \phi_0 = \frac{1}{2}mv_1^2$ ....(i)

Case I $\quad I5\phi_0 - \phi_0 = \frac{1}{2}mv_2^2$ ....(ii)

On dividing Eq. (i) by Eq. (ii), we get

$\frac{2\phi_0 - \phi_0}{5\phi_0 - \phi_0} = \frac{v_1^2}{\dots_2^2}$ or $\frac{v_1}{v_2} = \frac{1}{2}$

83 **(c)**
de-Broglie wavelength (λ) of a particle is related to its momentum (p), i.e. $\lambda = \frac{h}{p}$
where, h is Planck's constant.

or $\quad \lambda = \frac{h}{mv} \qquad (\because p = mv)$

or $\quad \lambda = \frac{h}{m\frac{v}{t} \cdot t} = \frac{h}{ma \cdot t} = \frac{h}{F \cdot t} \qquad (\because F = ma)$

$\Rightarrow \lambda$ is inversely proportional to impulse $(F \cdot t)$

84 **(c)**
Momentum, $p = mv = \frac{h}{\lambda}$

$$\Rightarrow \quad v = \frac{h}{m\lambda} = \frac{6.62 \times 10^{-34}}{9.1 \times 10^{-31} \times 5.2 \times 10^{-7}}$$

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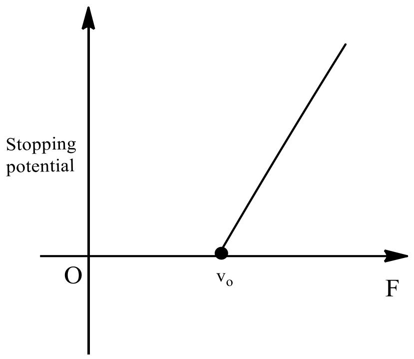
$= \frac{6.62\times10^4}{9.1\times5.2} = 1.4\times10^3\ \text{ms}^{-1} = 1400\ \text{ms}^{-1}$

85 **(a)**

The graph showing the variation of stopping potential with the frequency is shown below.



86 **(c)**

We can write, $\frac{1}{2}\text{mv}^2 = \text{eV}$

$$\Rightarrow \quad v = \sqrt{\frac{2eV}{m}} = \sqrt{2V\times\frac{e}{m}}$$

$$\text{or}\ \ v = \sqrt{2\times0.71\times1.76\times10^{11}}$$

$$= 5\times10^5\ \text{ms}^{-1} = 500\text{kms}^{-1}$$

87 **(b)**

Photons are the packets of energy (or energy particle) which are emitted by a source of radiation.

Energy possessed by a photon is given by $E = hv = \frac{hc}{\lambda}$

If power of each photon is P, then energy given out in t second is equal to Pt. Let the number of photons be n, then

$$n = \frac{Pt}{E} = \frac{Pt}{\left(\frac{hc}{\lambda}\right)} = \frac{Pt\lambda}{hc}$$

For red light, $n_R = \frac{Pt\lambda_R}{hc}$

For violet light, $n_V = \frac{Pt\lambda_V}{hc}$

$\because\ \frac{n_R}{n_V} = \frac{\lambda_R}{\lambda_V}$

As $\lambda_R > \lambda_V$ · So, $n_R > n_V$

88 **(c)**

Threshold wavelength, $\lambda_0 = \frac{hc}{\phi_0} = \frac{12400}{4}$

$$= 3100\text{Å}$$

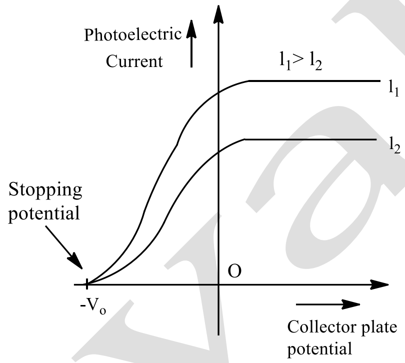
$$= 310\ \text{nm}$$

89 **(d)**

Threshold wavelength for lithium metal is 6250 A. For photoemission, the wavelength of the incident light must be equal to or less than 6250 A.

90 **(d)**

Variation of photoelectric current with collector plate potential for different intensities is shown correctly below as



Here for greater intensity I_1, more photoelectrons are emitted and hence, saturation current is more. Thus, graph corresponding to I_1 will be above than that of I_2. Since, the stopping potential is independent of intensity, hence the graphs converge at same value of stopping potential V_0 for both the intensities I_1 and I_2.

91 **(d)**

When a photon enters glass from air, the energy of photon does not change, while its wavelength and velocity change and hence, momentum (mv) also changes.

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