Single Correct Answer Type

1. The potential difference applied to an X-ray tube is V. The ratio of the de Broglie wavelength of electron to the minimum wavelength of X-ray is directly proportional to
a) V b) $\sqrt{V}$ c) $V^{3/2}$ d) $V^{7/2}$

2. Two identical photocathodes receive light of frequencies f_1 and f_2. If the velocities of the photoelectrons (of mass m) coming out are v_1 and v_2, respectively, then
a) $v_1 - v_2 = \left[\frac{2h}{m}(f_1 - f_2)\right]^{1/2}$ b) $v_1^2 - v_2^2 = \frac{2n}{m}(f_1 - f_2)$
c) $v_1 + v_2 = \left[\frac{2h}{m}(f_1 - f_2)\right]^{1/2}$ d) $v_1^2 + v_2^2 = \frac{2h}{m}(f_1 - f_2)$

3. Light of wavelength λ from a small 0.5 mW He-Ne laser source, used in the school laboratory, shines from a spacecraft of mass 1000 kg. Estimate the time needed for the spacecraft to reach a velocity of 1.0 km s^{-1} from rest. The momentum p of a photon of wavelength λ is given by $p = h/\lambda$, where h is Plank's constant
a) 6×10^{18} b) 3×10^{17} c) 6×10^{17} d) 2×10^{15}

4. The potential difference applied to an X-ray tube is increased. As a result, in the emitted radiation
a) The intensity increases b) The minimum wavelength increases
c) The intensity decreases d) The minimum wavelength decreases

5. The binding energy of the innermost electron in tungsten is 40 keV. To produce characteristic X-rays using a tungsten target in an X-rays tube the potential difference V between the cathode and the anti-cathode should be
a) $V < 40\ kV$ b) $V \leq 40\ kV$ c) $V > 40\ kV$ d) $V >/< 40\ kV$

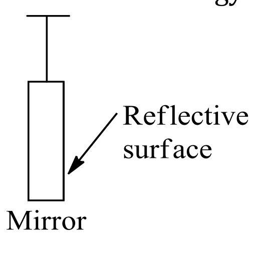
6. If a surface ahs work function of 3.00 eV, the longest wavelength of light which will cause the emission of electrons is
a) 4.8×10^{-7} m b) 5.99×10^{-7} m c) 4.13×10^{-7} m d) 6.84×10^{-7}m

7. A particle of mass 'm' is projected from ground with velocity 'u' making angle 'θ' with the vertical. The de Broglie wavelength of the particle at the highest point is
a) ∞ b) $h/mu \sin\theta$ c) $h/mu\ \cos\theta$ d) h/mu

8. The radius of second orbit of an electron in hydrogen atom is 2.116 Å. The de Broglie wavelength associated with this electron in this orbit would be
a) 6.64 Å b) 1.058 Å c) 2.116 Å d) 13.28 Å

9. A surface irradiated with light $\lambda = 480$ nm gives out electrons with maximum velocity v m/s, the cut off wavelength being 600 nm. The same surface would release electrons with maximum velocity $2v$ m/s if it is irradiated by light of wavelength
a) 325 nm b) 360 nm c) 384 nm d) 300 nm

10. A small mirror of mass m is suspeneded by a light thread of length ℓ. A short pulse of laser falls on the mirror with energy E. Then, which of the following statement is correct?



a) If the pulse falls normally on the mirror, it deflects by $\theta = 2E/(mc\sqrt{2g\ell})$
b) If the pulse falls normally on the mirror, it deflects by $\theta = 2E/(mc\sqrt{2g})$
c) Impulse in thread depends on angle at which the pulse falls on the mirror
d) None of the above

11. A cesium photocell, with a steady potential difference of 60 V across it, is illuminated by a small bright

light placed 1 m away. When the same light is placed 2 m away, the electrons crossing the photocell

a) Each carry one-quarter of their previous momentum
b) Each carry one-quarter of their previous energy
c) Are one-quarter as numerous
d) Are half as numerous

12. Given that a photon of light of wavelength 10, 000 Å has an energy equal to 1.23 eV. When light of wavelength 5000 Å and intensity I_0 falls on a photoelectric cell, the saturation current is 0.40×10^{-6} A and the stopping potential is 1.36 V, if the intensity of light is made $4I_0$, then the saturation current will become

a) 0.40×1 μA
b) 0.40×2 μA
c) 0.40×4 μA
d) 0.40×8 μA

13. All electrons ejected from a surface by incident light of wavelength 200 nm can be stopped before travelling 1 m in the direction of a uniform electric field of 4 NC^{-1}. The work function of the surface is

a) 4 eV b) 6.2 eV c) 2 eV d) 2.2 eV

14. How many photons of a radiation of wavelength $\lambda = 5 \times 10^{-7}$ m must fall per second on a blackened plate in order to produce a force of 6.62×10^{-5} N?

a) 3×10^{19} b) 5×10^{22} c) 2×10^{22} d) 1.67×10^{18}

15. An α-particle and a proton are fired through the same magnetic fired which is perpendicular to their velocity vectors. The α-partcle and the proton move such that radius of curvature of their paths is same. Find the ratio of their de Broglie wavelengths

a) 2:3 b) 3:4 c) 5:7 d) 1:2

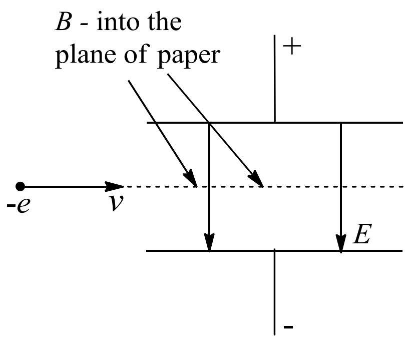
16. The threshold frequency for certain metal is v_0. When light of frequency $2v_0$ is incident on it, the maximum velocity of photoelectrons is 4×10^6 ms^{-1}. If the frequency of incident radiation is increased to $5v_0$, then the maximum velocity of photoelectrons will be

a) $4/5 \times 10^6$ ms^{-1} b) 2×10^6 ms^{-1} c) 8×10^6 ms^{-1} d) 2×10^7 ms^{-1}

17. The human eye is most sensitive to green light of wavelength 505 nm. Experiments have found that when people are kept in a dark room until their eyes adapt to the darkness, a single photon of green light will trigger receptor cells in the rods of the retina. The velocity of typical bacterium of mass 9.5×10^{-12} g, if it had absorbed all energy of photon, is nearly

a) 10^{-6} ms^{-1} b) 10^{-8} ms^{-1} c) $10^{-10}$$ms^{-1}$ d) 10^{-13} ms^{-1}

18. Electrons traveling at a velocity of 2.4×10^6 ms^{-1} enter a region of crossed electric and magnetic fileds shown in Figure. If the electric field is 3.0×10^6 Vm and the flux density of the magnetic field is 1.5 T, the electrons upon entering the region of the crossed fields will



a) Continue to travel undeflected in their original direction
b) Be deflected upward in the plane of the diagram
c) Be deflected downward on the plane of the diagram
d) None of the above

19. X-rays are produced in X-ray tube operating at a given accelerating voltage. The wavelength of the continuous X-rays has values from

a) 0 to ∞ b) $\lambda_{\min}$ to ∞, where $\lambda_{\min} > 0$
c) 0 to $\lambda_{\max}$, where $\lambda_{\max} < \infty$ d) $\lambda_{\min}$ to $\lambda_{\max}$, where $0 < \lambda_{\min} < \lambda_{\max} < \infty$

20. The energy of a photon is equal to the kinetic energy of a photon. The energy of a the photon is E. Let λ_1 be the de-Broglie wavelength of the photon and λ_2 be the wavelength of the photon. The ratio $\frac{\lambda_1}{\lambda_2}$ proportional to
a) E^0 b) $E^{1/2}$ c) E^{-1} d) E^{-2}

21. The X-ray beam coming from an X-ray tube will be
a) Monochromatic
b) Having all wavelengths smaller than a certain maximum wavelength
c) Having all wavelengths larger than a certain minimum wavelength
d) Having all wavelengths lying between a minimum and a maximum wavelength

22. Representing the stopping potential V along y-axis and $(1/\lambda)$ along x-axis for a given photocathode, the curve is a straight line, the intercept on the y-axis is equal to
a) $+W/e$ b) $-W/e$ c) $-We$ d) e/W

23. Light of wavelength λ strikes a photoelectric surface and electrons are ejected with kinetic energy K. If K is to be increased to exactly twice its original value, the wavelength must be changed to 'λ' such that
a) $\lambda' < \lambda/2$ b) $\lambda' > \lambda/2$ c) $\lambda > \lambda' > \lambda/2$ d) $\lambda' = \lambda/2$

24. Five volt of stopping potential is needed for the photoelectrons emitted out of a surface of work function 2.2 eV by the radiation of wavelength
a) 1719 Å b) 3444 Å c) 861 Å d) 3000 Å

25. The minimum orbital angular momentum of the electron in a hydrogen atom is
a) h b) $h/2$ c) $h/2\pi$ d) h/λ

26. The de Broglie wavelength of a thermal neutron at 927°C is λ. Its wavelength at 327°C will be
a) $\lambda/2$ b) $\lambda/\sqrt{2}$ c) $\lambda\sqrt{2}$ d) 2λ

27. Representing the stopping potential V along y-axis and $(1/\lambda)$ along x-axis for a given photocathode, the curve is a straight line, the slope of which is equal to
a) e/hc b) hc/e c) ec/h d) he/c

28. Photoelectric work function of a metal is 1 eV. Light of wavelength $\lambda = 3000$ Å falls on it. The photoelectrons come out with velocity
a) 10 ms^{-1} b) 10^3 ms^{-1} c) 10^4 ms^{-1} d) 10^6 ms^{-1}

29. The work function of a metal is W and λ is the wavelength of the incident radiation. There is no emission of photoelectrons when
a) $\lambda > hc/W$ b) $\lambda = hc/W$ c) $\lambda < hc/W$ d) $\lambda \leq hc/W$

30. When a metallic surface is illuminated by a light of frequency 8×10^{14} Hz, photoelectron of maximum energy 0.5 eV is emitted. When the same surface is illuminated by light of frequency 12×10^{14} Hz, photoelectron of maximum energy 2 eV is emitted. The work function is
a) 0.5 eV b) 2.85 eV c) 2.5 eV d) 3.5 eV

31. The frequency and the intensity of a beam of light falling on the surface of a photoelectric material are increased by a factor of two. This will
a) Increase the maximum kinetic energy, the photoelectrons, as well as photoelectric current by a factor of 2
b) Increase the maximum kinetic energy of the photoelectron and would increase the photoelectric current by a factor of 2
c) Increase the maximum kinetic energy of the photoelectrons by a factor of 2 and will have no effect on the magnitude of the photoelectric current produced
d) Not produce any effect on the kinetic energy of the emitted electrons but will increase the photoelectric current by a factor of 2

32. Light from a hydrogen discharge tube is incident on the cathode of a photoelectric cell. The work function of the cathode surface is 4.2 eV. In other to reduce the photocurrent to zero, the voltage of the anode relative to the cathode must be made

a) −4.2 V b) −9.4 V c) −17.8 V d) +9.4 V

33. A modern 200 W sodium street lamp emits yellow light of wavelength 0.6 μm. 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) 62×10^{20} b) 3×10^{19} c) 1.5×10^{20} d) 6×10^{18}

34. Given that a photon of light of wavelength 10, 000 Å has an energy equal to 1.23 eV. When light of wavelength 5000 Å and intensity I_0 falls on a photoelectric cell, the saturation current is 0.40×10^{-6} A and the stopping potential is 1.36 V, if the cathode and the anode are kept at the same potential, the emitted electrons

a) All have the same KE equal to 1.36 eV

b) All have the average KE equal to (1.36/2) eV

c) All have the maximum KE equal to 1.36 eV

d) All have the minimum KE equal to 1.36 eV

35. Monochromatic light incident on a metal surface emits electrons with kinetic energies from zero to 2.6 eV. What is the least energy of the incident photon if the tightly bound electron needs 4.2 eV to remove?

a) 1.6 eV b) From 1.6 eV to 6.8 eV c) 6.8 eV d) More than 6.8 eV

36. The kinetic energy of an electron is E when the incident wavelength is λ. To increase the KE of the electron to $2E$, the incident wavelength must be

a) 2λ b) $\lambda/2$ c) $(hc\lambda)(E\lambda + hc)$ d) $(hc\lambda)/(E\lambda + hc)$

37. A monochromatic source of light is placed at a large distance d from a metal surface. Photoelectrons are ejected at rate n, the kinetic energy being E. If the source is brought nearer to distance $d/2$, the rate and kinetic energy per photoelecton become nearly

a) $2n$ and $2E$ b) $4n$ and $4E$ c) $4n$ and E d) n and $4E$

38. Light of wavelength 0.6 μm from a sodium lamp falls on a photocell and cause the emission of photoelectrons for which the stopping potential is 0.5 V. With light of wavelength 0.04 μm from a mercury vapor lamp, the stopping potential is 1.5 V. Then, the work function [in electron volts] of the photocell surface is

a) 0.75 eV b) 1.5 eV c) 3 eV d) 2.5 eV

39. What is the energy of a proton possessing wavelength 0.4 Å?

a) 0.51 eV b) 1.51 eV c) 10.51 eV d) 100.51 eV

40. 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 per second 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) $2.13 \times 10^{11}\ s^{-1}$

41. Two identical metal plates show photoelectric effect. Light of wavelength λ_A falls on plate A and λ_B falls on plate B, $\lambda_A = 2\lambda_B$. The maximum KE of the photoelectrons are K_A and K_B, respectively. Which one of the following is true?

a) $2K_A = K_B$ b) $K_A = 2K_B$ c) $K_A < K_B/2$ d) $K_A > 2K_B$

42. A sodium metal piece is illuminated with light of wavelength 0.3 μm. The work function of sodium is 2.46 eV. For this situation, mark out the correct statement(s)

a) The maximum kinetic energy of the ejected photoelectrons is 1.68 eV

b) The cut-off wavelength for sodium is 505 nm

c) The minimum photon energy of incident light for photoelectric effect to take place is 2.46 eV

d) All of the above

43. 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) $\sqrt{2m_e/m_\alpha}$ c) $\sqrt{m_e/m_\alpha}$ d) $\sqrt{m_e/2m_\alpha}$

44. Upto what potential V can a zinc ball (work function 3.74 eV) removed from other bodies be charged by irradiating it with light of $\lambda = 200$ nm?

a) 2.5 V b) 1.8 V c) 2.2 V d) 3 V

45. If λ_0 stands for mid-wavelength in the visible region, the de Broglie wavelength for 100 V electrons is nearest to

a) $\lambda_0/5$ b) $\lambda_0/50$ c) $\lambda_0/500$ d) $\lambda_0/5000$

46. The de Broglie wavelength of neutrons in thermal equilibrium is (Given $m_n = 1.6 \times 10^{-27}$ kg)

a) $30.8/\sqrt{T}$ Å b) $3.08/\sqrt{T}$ Å c) $0.308/\sqrt{T}$ Å d) $0.0308/\sqrt{T}$ Å

47. The kinetic energy of a particle is equal to the energy of a photon. The particle moves at 5% of the speed of light. The ratio of the photon wavelength to the de Broglie wavelength of the particle is [No need to use relative formula for the particle]

a) 40 b) 4 c) 2 d) 80

48. The shortest wavelength of X-rays emitted from an X-ray tube depends on the

a) Current in the tube b) Voltage applied to the tube

c) Nature of gas in the tube d) Atomic number of target material

49. A material particle with a rest mass m_0 is moving with a velocity of light c. Then, the wavelength of the de Broglie wave associated with it is

a) $(h/m_0 c)$ b) Zero c) ∞ d) $(m_0\, c/h)$

50. Work function of nickel is 5.01 eV. When ultraviolet radiation of wavelength 200 Å is incident on it, electrons are emitted. What will be the maximum velocity of emitted electrons?

a) 3×10^8 ms^{-1} b) 6.46×10^5 ms^{-1} c) 10.36×10^5 ms^{-1} d) 8.54×10^6 ms^{-1}

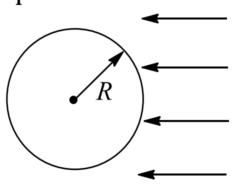
51. The photoelectric threshold for some material is 200 nm. The material is irradiated with radiations of wavelength 40 nm. The maximum kinetic energy of the emitted photoelectric is

a) 2 eV b) 1 eV c) 0.5 eV d) None of these

52. A sensor is exposed for time t to a lamp of power P placed at a distance ℓ. The sensor has an opening that is $4d$ in diameter. Assuming all energy of the lamp is given off as light, the number of photons entering the sensor if the wavelength of light is λ is

a) $N = P\lambda d^2 t/hc\ell^2$ b) $N = 4P\lambda d^2 t/hc\ell^2$ c) $N = P\lambda d^2 t/4hc\ell^2$ d) $N = P\lambda d^2 t/16hc\ell^2$

53. A plane wave of intensity $I = 0.70$ W cm^{-2} illuminates a sphere with ideal mirror surface. The radius of sphere is $R = 5.0$ cm. From the standpoint of photon theory, find the force that light exerts on the sphere



a) 0.8 μN b) 0.2 μN c) 0.5 μN d) 1.2 μN

54. A photon of wavelength 0.1 Å is emitted by a helium atom as a consequence of the emission of photon. The KE gained by helium atom is

a) 0.05 eV b) 1.05 eV c) 2.05 eV d) 3.05 eV

55. A homogenous ball (mass= m) of ideal black material at rest, is illuminated with a radiation having a set of photons (wavelength = λ) each with same momentum and same energy. The rate at which photons fall on the ball is n. The linear acceleration of the ball is

a) $m\lambda/nh$ b) $nh/m\lambda$ c) $nh/(2\pi)(m\lambda)$ d) $2pm\lambda/nh$

56. Radiation of wavelength 546 nm falls on a photon cathode and electrons with maximum kinetic energy of 0.18 eV are emitted. When radiation of wavelength 185 nm falls on the same surface, a (negative) stopping potential of 4.6 V has to be applied to the collector cathode to reduce the photoelectric current to zero. Then, the ratio h/e is

a) 6.6×10^{-15} Js C^{-1} b) 4.12×10^{-15} Js C^{-1} c) 6.6×10^{-34} Js C^{-1} d) 4.12×10^{-34} Js C^{-1}

57. K_α wavelength emitted by an atom of atomic number Z =11 is λ. Find the atomic number for an atom that emits K_α radiation with wavelength 4λ

a) Z = 6 b) Z = 4 c) Z =11 d) Z = 44

58. If a surface has a work function 4.0 eV, what is the maximum velocity of electrons liberated from the surface when it is irradiated with ultraviolet radiation of wavelength 0.2 μm?

a) 4.4×10^5 ms^{-1} b) 8.8×10^7 ms^{-1} c) 8.8×10^5 ms^{-1} d) 4.4×10^7 ms^{-1}

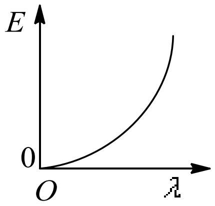
59. The kinetic energy of most energetic electrons emitted from a metallic surface is doubled when the wavelength λ of the incident radiation is changed from 400 nm to 310 nm. The work function of the metal is

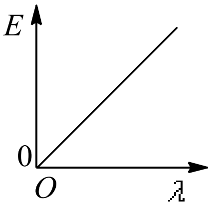
a) 0.9 eV b) 1.7 eV c) 2.2 eV d) 3.1 eV

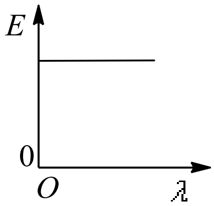
60. The KE of the photoelectrons is E when the incident wavelength is $\lambda/2$. The KE becomes $2E$ when the incident wavelength is $\lambda/3$. The work function of the metal is

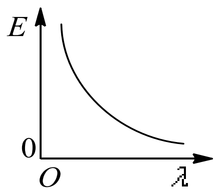
a) hc/λ b) $2hc/\lambda$ c) $3hc/\lambda$ d) $hc/3\lambda$

61. Which curve shows the relationship between the energy E and the wavelength λ of a photon of electromagnetic radiation?

a) 

b) 

c) 

d) 

62. A particle of mass M at rest decays into two masses m_1 and m_2 with non-zero velocities. The ratio λ_1/λ_2 of de Broglie wavelengths of the particles is

a) m_2/m_1 b) m_1/m_2 c) $\sqrt{m_1}/\sqrt{m_2}$ d) 1: 1

63. An image of the Sun is formed by a lens, of focal length of 30 cm, on the metal surface of a photoelectric cell and a photoelectric current I is produced. The lens forming the image is then replaced by another of the same diameter but of focal length 15 cm. the photoelectric current in this case is

a) $\frac{I}{2}$ b) I c) $2I$ d) $4I$

64. Which one of the following statement is wronge in the context of X-rays generated from X-ray tube?

a) Wavelength of characteristic X-rays decreases when the atomic number of the target increases
b) Cut-off wavelength of the continuous X-rays depends on the atomic number of the target
c) Intensity of the characteristic X-rays depends on the electrical power given to the X-ray tube
d) Cut-off wavelength of the continuous X-rays depends on the energy of the electrons in X-ray tube

65. When a centimeter thick surface is illuminated with light of wavelength λ, the stopping potential is V. When the same surface is illuminated by light of wavelength 2λ, the stopping potential is $V/3$. Threshold wavelength for the metallic surface is

a) $4\lambda/3$ b) 4λ c) 6λ d) $8\lambda/3$

66. An electron beam accelerated from rest through a potential difference of 5000 V in vacuum is allowed to impinge on a surface normally. The incident current is 50 μA and if the electrons come to rest on striking the surface the force on it is

a) 1.1924×10^{-8} N b) 2.1×10^{-8} N c) 1.6×10^{-8} N d) 1.6×10^{-6} N

67. A proton when accelerated through a potential difference of V volt has a wavelength λ associated with it. An α-particle in order to have the same λ must be accelerated through a potential difference of

a) V volt b) $4V$ volt c) $2V$ volt d) $(V/8)$ volt

68. In above question the energy of the characteristic X-rays given out is

a) Less than 40 keV b) More than 40 keV c) Equal to 40 keV d) $\geq$ 40 keV

69. The frequency of incident light falling on a photosensitive metal plate is doubled, the KE of the emitted photoelectrons is

a) Double the earlier value b) Unchanged
c) More than doubled d) Less than doubled

70. The wavelength of K_a X-rays produced by an X-ray tube is 0.76 Å. The atomic number of the anode material of the tube is

a) 20 b) 60 c) 40 d) 80

71. What is the wavelength of a photon of energy 1eV?

a) 12.4×10^3 Å b) 2.4×10^3 Å c) 0.4×10^2 Å d) 1000 Å

72. An electron is accelerated through a potential difference of V volt. If has a wavelength λ associated with it.

Through what potential difference an electron must be accelerated so that its de Broglie wavelength is the same as that of a proton? Take mass of proton to be 1837 times larger than the mass of electron

a) V volt b) 1837 V volt c) $V/1837$ volt d) $\sqrt{1837}\,V$ volt

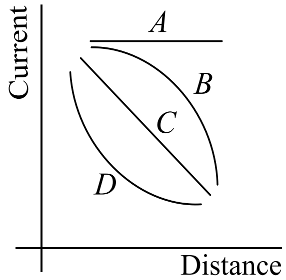
73. An electron and a photon posses the same de Broglie wavelength. If E_e and E_{ph} are, respectively, if the velocity of electron is 25% of the velocity of photon, then E_e/E_{ph} equals

a) 1:2 b) 1:4 c) 1:8 d) 1:16

74. Lights of two different frequencies whose photons have energies 1 and 2.5 eV, respectively, successively illuminate a metal whose work function is 0.5 eV. The ratio of the maximum speeds of the emitted electrons will be

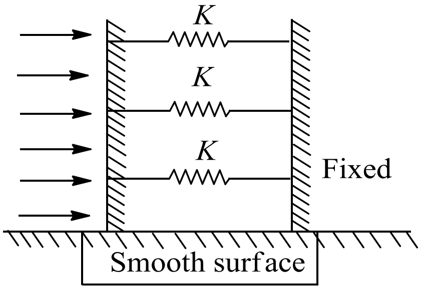
a) 1:5 b) 1:4 c) 1:2 d) 1:1

75. A point source causes photoelectric effect from a small metal place. Which of the curves in Figure may represent the saturation photo-current as a function of the distance between the source and the metal?



a) A b) B c) C d) D

76. Light of intensity I is incident perpendicularly on a perfectly reflecting plate of area A kept in a gravity-free space. If the photons strike the plate symmetrically and initially the spring was at its natural length, find the maximum compression in the springs



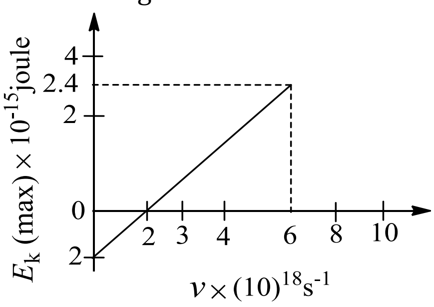
a) IA/Kc b) $2Ia/3Kc$ c) $3Ia/Kc$ d) $4Ia/3Kc$

77. In a series of photoelectric emission experiments on a certain metal surface, possible relationships between the following quantities were investigated: threshold frequency f_0, frequency of incident light f, light intensity P, photocurrent I, maximum kinetic energy of photoelectrons T_{max}. Two of these quantities, when plotted as a graph as a graph of y agianst x, give a straight line through the origin

Which of the following correctly identifies x and y with the photoelectric quantities?

	x	y
a)	I	f_0
b)	f	f_0
c)	P	I
d)	P	T_{max}

78. In the experiment on photoelectric effect, the graph between $E_{K(max)}$ and v is found to be a straight line as shown in Figure

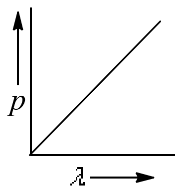


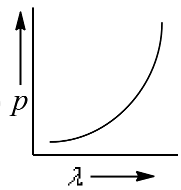
The threshold frequency and the Planck's constant according to this graph are

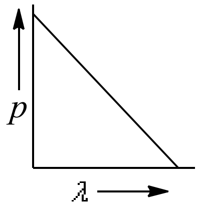
a) $3.33 \times 10^{18}\ s^{-1}, 6 \times 10^{-34}\ J-s$ b) $6 \times 10^{18}\ s^{-1}, 6 \times 10^{-34}\ J-s$

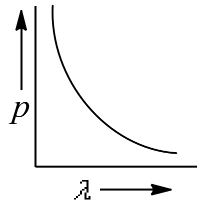
c) $2.66 \times 10^{18}\ s^{-1}, 4 \times 10^{-34}\ J-s$ d) $4 \times 10^{18}\ s^{-1}, 3 \times 10^{-34}\ J-s$

79. Which of the following graphs correctly represents the variation of particle momentum with associated de Broglie wavelength?

a) 

b) 

c) 

d) 

80. If a photocell is illuminated with a radiation of 1240 Å, then stopping potential is found to be 8 V. The work function of the emitter and the threshold wavelength are

a) 1 eV, 5200 Å b) 2 eV, 6200 Å c) 3 eV, 7200 Å d) 4 eV, 4200 Å

81. When a certain metallic surface is illuminated with monochromatic light of wavelength λ, the stopping potential for photoelectric current is $3V_0$ and when same surface is illuminated with light of wavelength 2λ, the same stopping potential is V_0. The threshold wavelength of this surface for photoelectric effect is

a) 6λ b) $4\lambda/3$ c) 4λ d) 8λ

82. A photosensitive material is at 9 m to the left of the origin and the source of light is at 7 m to the right of the origin along x-axis. The photosensitive material and the source of light start from rest and move, respectively, with $8\hat{\imath}$ ms^{-1} and $4\hat{\imath}$ ms^{-1}. The ratio of intensities at $t = 0$ to $t = 3$ as received by the photosensitive material is

a) 16:1 b) 1:16 c) 2:7 d) 7:2

83. 10^{-3} W of 5000 Å light is directed on a photoelectric cell. If the current in the cell is 0.16 μA, the percentage of incident photons which produce photoelectrons, is

a) 40% b) 0.04% c) 20% d) 10%

84. The K_a X-ray emission line of tungsten occurs at $\lambda = 0.021nm$. The energy difference between K and L levels in this atom is about

a) 0.51 MeV b) 1.2 MeV c) 59 KeV d) 13.6 eV

85. In a photocell, with excitation wavelength λ, the faster electron has speed v. If the excitation wavelength is changed to $3\lambda/4$, the speed of the fastest electron will be

a) $v(3/4)^{1/2}$ b) $v(4/3)^{1/2}$

c) Less than $v(4/3)^{1/2}$ d) Greater than $v(4/3)^{1/2}$

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

a) 540 nm b) 400 nm c) 310 nm d) 220 nm

87. An electron is accelerated through a potential difference of 200 V. If e/m for the electron be 1.6×10^{11} coulomb kg^{-1}, then the velocity acquired by the electron will be

a) 8×10^6 ms^{-1} b) 8×10^5 ms^{-1} c) 5.9×10^6 ms^{-1} d) 5.9×10^5 ms^{-1}

88. Silver has a work function of 4.7 eV. When ultraviolet light of wavelength 100 mm is incident upon 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 the photoelectrons when light of wavelength 200 mm is incident upon silver?

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

89. Given that a photon of light of wavelength 10, 000 Å has an energy equal to 1.23 eV. When light of wavelength 5000 Å and intensity I_0 falls on a photoelectric cell, the saturation current is 0.40×10^{-6} A and the stopping potential is 1.36 V; then the work function is

a) 0.43 eV b) 1.10 eV c) 1.36 eV d) 2.47 eV

90. If the short wavelength limit of the continuous spectrum coming out of a Coolidge tube is 10 Å, then the de Broglie wavelength of the electrons reaching the target metal in the Coolidge tube is approximately

a) 0.3 Å b) 3 Å c) 30 Å d) 10 Å

91. If stopping potentials corresponding to wavelengths 4000 Å and 4500 Å are 1.3 V and 0.9 V, respectively, then the work function of the metal is

a) 0.3 eV b) 1.3 eV c) 2.3 eV d) 5 eV

92. Given that a photon of light of wavelength 10, 000 Å has an energy equal to 1.23 eV. When light of wavelength 5000 Å and intensity I_0 falls on a photoelectric cell, the saturation current is 0.40×10^{-6} A and the stopping potential is 1.36 V, if the wavelength is changed to 4000 Å, then stopping potential will become

a) 1.36 V
b) 3.40 V
c) 1.60 V
d) 1.97 V

93. 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) 4.5

94. An electron and a photon posses the same de Broglie wavelength. If E_e and E_{ph} are, respectively, the energies of electron and photon while v and c are their respective velocities, then $E_e/E_{ph} =$

a) v/c b) $v/2c$ c) $v/3c$ d) $v/4c$

95. X-rays are used to irradiate sodium and copper surface in two separate experiments and stopping potentials are determined. The stopping potential is

a) Equal in both cases b) Greater for sodium c) Greater for copper d) Infinite in both cases

96. The human eye can barely detect a yellow light ($\lambda = 6000$ Å) that delivers 1.7×10^{-18} W to the retina. The number of photons per second falling on the eye is nearest to

a) 5×10^9 b) 5000 c) 50 d) 5

97. A plane light wave of intensity $I = 0.20$ W cm^{-2} falls on a plane mirror surface with reflection coefficient $\rho = 0.8$. The angle of incidence is 45°. In terms of corpuscular theory, find the magnitude of the normal pressure exerted on that surface

a) 1.2 N cm^{-2} b) 0.2 N cm^{-2} c) 2.6 N cm^{-2} d) 0.5 N cm^{-2}

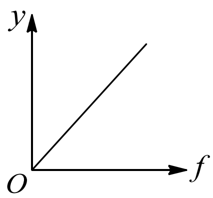
98. The maximum velocity of electrons emitted from a metal surface is v. What would be the maximum velocity if the frequency of incident light is increased by a factor of 4?

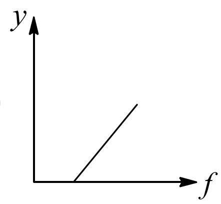
a) $2v$ b) $> 2v$ c) $< 2v$ d) Between $2v$ and $4v$

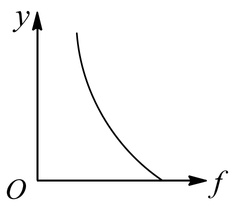
99. The work functions for tungsten and sodium are 4.5 eV and 2.3 eV, respectively. If the threshold wavelength λ for sodium is 5460 Å, the value of λ for tungsten is

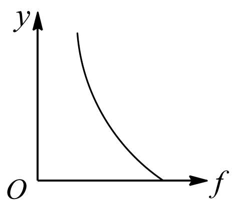
a) 5893 Å b) 10683 Å c) 2791 Å d) 528 Å

100. In an experiment on the photoelectric effect, an evacuated photocell with a pure metal cathode is used. Which graph best represents the variation of V, the minimum potential difference needed to prevent current from flowing, when x, the frequency of the incident light, is varied?

a) 

b) 

c) 

d) 

101. The work function for sodium surface is 2.0 eV and that for aluminium surface is 4.2 eV. The two metals are illuminated with appropriate radiations so as to cause photoemission. Then

a) The threshold frequency for sodium will be less than that for aluminium
b) The threshold frequency of sodium will be more than that of aluminium
c) Both sodium and aluminium will have same threshold frequency
d) None of the above

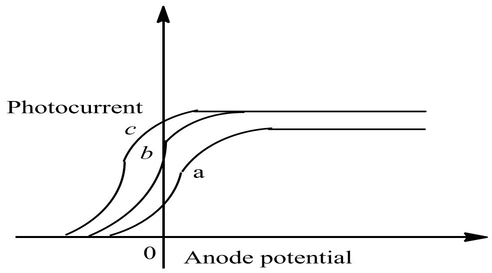
102. With respect to Electromagnetic Theory of Light, the photoelectric effect is best explained by statement

a) Light waves carry energy and when light is incident on the metallic surface, the energy absorbed by the metal may somehow concentrate on individual electrons and reappear as their kinetic energy when ejected
b) Particles of light (photons) collide with the metal and the electrons take this energy and may eject
c) When light waves fall on a metallic surface, the stability of atoms is disturbed and the electrons come out to make the system stable
d) None of the above

103. In a photoelectric effect, electrons are emitted
a) With a maximum velocity proportional to the frequency of the incident radiation
b) At a rate that is independent of the intensity of the incident radiation
c) Only if the frequency of the incident radiation is above a certain threshold value
d) Only if the temperature of the emitter is high

104. A metal surface is illuminated by a 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 emitted photoelectrons will become
a) $(1/16)^{\text{th}}$ of original value b) Unchanged
c) Twice the original value d) Four times the original value

105. The figure shows variation of photocurrent with anode potential for a photo-sensitive surface for three different radiations. Let I_a, I_b and I_c be the intensities and v_a, v_b and v_c be the frequencies for the curves a, b and c respectively. Then

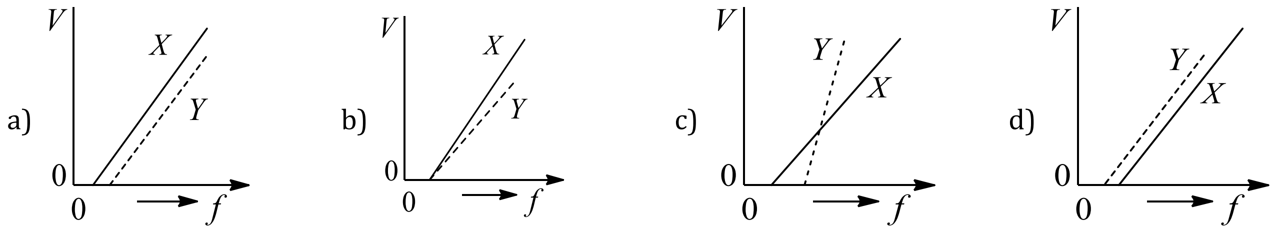


a) $v_a = v_b and\ I_a \neq I_b$ b) $v_a = v_c$ and $I_a = I_c$ c) $v_a = v_b$ and $I_a = I_b$ d) $v_b = v_c$ and $I_b = I_c$

106. The work function of a metallic surface is 5.01 eV. The photoelectrons are emitted when light of wavelength 2000 Å falls on it. The potential difference applied to stop the fastest photoelectrons is $[h = 4.14 \times 10^{-15}$ eVs]
a) 1.2 V b) 2.24 V c) 3.6 V d) 4.8 V

107. Out of a photon and an electron, the equation $E = pc$, is valid for
a) Both b) Neither c) Photon only d) Electron only

108. In a photoelectric emission, electrons are ejected from metals X and Y by light of frequency f. The potential difference V required to stop the electrons is measured for various frequencies. If Y has a greater work function than X, which graph illustrates the expected results?



109. In the previous question, if the intensity of light is made $4I_0$, then the stopping potential will become
a) 1.36 × 1 V b) 1.36 × 2 V c) 1.36 × 3 V d) 1.36 × 4 V

110. An electron and a photon, each has a wavelength of 1.2 Å. What is the ratio of their energies?
a) 1:10 b) $1: 10^2$ c) $1: 10^3$ d) $1: 10^4$

111. How many photons are emitted per second by a 5 mW laser source operating at 632.8 nm?
a) 1.6×10^{16} b) 1.6×10^{13} c) 1.6×10^{10} d) 1.6×10^3

112. The energy of a photon is equal to the kinetic energy of a proton. The energy of photon is E. Let λ_1 be the

de Broglie wavelength of the proton and λ_2 be the wavelength of the photon. Then, λ_1/λ_2 is proportional to

a) E^0 b) $E^{1/2}$ c) E^{-1} d) E^{-2}

113. Find the ratio of de Broglie wavelength of a proton and an α-particle which have been accelerated through same potential difference

a) $2\sqrt{2}:1$ b) 3:2 c) $3\sqrt{2}:1$ d) 2:1

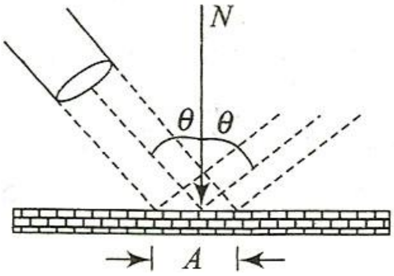
114. Let p and E denote the linear momentum and energy, respectively, of a photon. If the wavelength is decreased

a) Both p and E increase
b) p increases and E decreases
c) p decreases and E increases
d) Both p and E decrease

115. In a photoelectric cell, the wavelength of incident light is changed from 4000 Å to 3600 Å. The change in stopping potential will be

a) 0.14 V b) 0.24 V c) 0.35 V d) 0.44 V

116. A nozzle throws a stream of gas against a wall with a velocity v much larger than the thermal agitation of the molecules. The wall deflects the molecules without changing the magnitude of their velocity. Also, assume that the force exerted on the wall by the molecules is perpendicular to the wall. (This is not strictly true for a rough wall). Find the force exerted on the wall



a) $Anmv^2\cos^2\theta$ b) $2Anmv^2\cos^2\theta$ c) $2Anmv^2\sin^2\theta$ d) $Anmv^2\cos\theta$

117. 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

118. A particle of mass $3m$ at rest decays into two particles of masses m and $2m$ having non-zero velocities. The ratio of the de Broglie wavelengths of the particles (λ_1/λ_2) is

a) 1/2 b) 1/4 c) 2 d) None of these

119. What is the de Broglie wavelength of the wave associated with an electron that has been accelerated through a potential difference of 50.0 V?

a) 2.7×10^{-10} b) 1.74×10^{-10} c) 3.6×10^{-9} d) 4.9×10^{-11}

120. The eye can detect 5×10^4 photons $(m^2s)^{-1}$ of green light ($\lambda = 5000$ Å), while ear can detect 10^{-13} W m^{-2}. As a power detector, which is more sensitive and by what factor?

a) Eye is more sensitive and by a factor of 5.00
b) Ear is more sensitive by a factor of 5.00
c) Both are equally sensitive
d) Eye is more sensitive by a factor of 10^{-1}

121. A 60 W bulb is placed at a distance of 4 m from you. The bulb is emitting light of wavelength 600 nm uniformly in all directions. In 0.1 s, how many photons enter your eye if the pupil of the eye is having a diameter of 2 mm? [Take $hc = 1240$ eV-nm]

a) 2.84×10^{12} b) 2.84×10^{11} c) 9.37×10^{11} d) 6.48×10^{11}

122. A photon has same wavelength as the de Broglie wavelength of electrons. Given C = speed of light, v = speed of electron. Which of the following relation is correct? [Here E_e = kinetic energy of electron, E_{ph} = energy of photon, P_e =mometum of electron and P_{ph} =momentum of photon]

a) $E_e/E_{ph} = 2C/v$ b) $E_e/E_{ph} = v/2C$ c) $P_e/P_{ph} = 2C/v$ d) $P_e/P_{ph} = C/v$

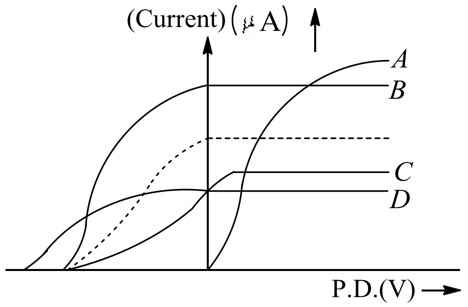
123. In the previous question, the work function is

a) 0.212 eV b) 0.313 eV c) 0.414 eV d) 0.515 eV

124. A particle of mass 10^{-31} kg is moving with a velocity equal to$10^5 ms^{-1}$. The wavelength of the particle is equal to

a) 0 b) 6.6×10^{-8} m c) 0.66 m d) 1.5×10^7 m

125. A photoelectric cell is connected to a source of variable potential difference, connected across it and the photoelectric current resulting (μA) is plotted against the applied potential difference (V). The graph in the broken line represents one for a given frequency and intensity of the incident radiation. If the frequency is increased and the intensity is reduced, which of the following graphs of unbroken line represents the new situation?



a) A b) B c) C d) D

126. Two electrons are moving with same speed v. One electron enters a region of uniform electric filed while the other enters a region of uniform magnetic field, then after some time de Broglie wavelengths of two are λ_1 and λ_2, respectively. Now,

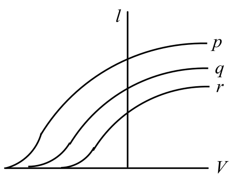
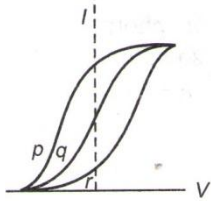
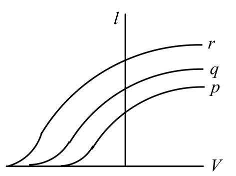
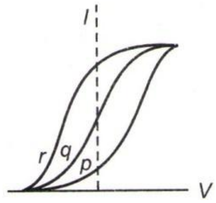
a) $\lambda_1 = \lambda_2$ b) $\lambda_1 > \lambda_2$
c) $\lambda_1 < \lambda_2$ d) λ_1 can be greater than or less than l_2

127. The photoelectric threshold of a certain metal is 3000 Å. If the radiation of 2000 Å is incident on the metal

a) Electrons will be emitted b) Positrons will be emitted
c) Protons will be emitted d) Electrons will not be emitted

128. 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 I-V graph for the experiment is

a) 
b) 
c) 
d) 

129. Two identical non-relativistic particles A and B move at right angles to each other, processing de Broglie wavelength λ_1 and λ_2, respectively. The de Broglie wavelength of each particle in their centre of mass frame of reference is

a) $\lambda_1 + \lambda_2$ b) $2\lambda_1\lambda_2/\left(\sqrt{\lambda_1^2 + \lambda_2^2}\right)$ c) $\lambda_1\lambda_2/(\sqrt{|\lambda_1^2 + \lambda_2^2|})$ d) $(\lambda_1 + \lambda_2)/2$

130. If the intensity of radiation incident on a photocell be increased four times, then number of photoelectrons and energy of photoelectrons emitted respectively become

a) Four times, doubled b) Doubled, remains unchanged
c) Remains unchanged, doubled d) For times, remains unchanged

131. Threshold frequency for a certain metal is v_0. When light of frequency $2v_0$ is incident on it, the maximum velocity of photoelectrons is 4×10^8 cms^{-1}. If frequency of incident radiation is increased to $5v_0$, then the maximum velocity of photoelectrons, in cm s^{-1}, will be

a) $(4/5) \times 10^8$ b) 2×10^8 c) 8×10^8 d) 20×10^8

132. For the structural analysis of crystals, X-rays are used because

a) X-rays have wavelength of the order of interatomic spacing
b) X-rays are highly penetrating radiations

c) Wavelength of X-rays is of the order of nuclear size
d) X-rays are coherent radiations

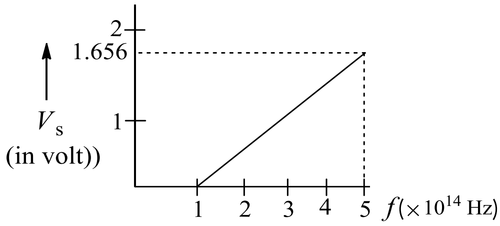
133. If λ_1 and λ_2 denote the wavelengths of de Broglie waves for electrons in the first and second Bohr orbits in a hydrogen atom, then λ_1/λ_2 is equal to

a) 2/1 b) 1/2 c) 1/4 d) 4/1

134. 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) $\lambda_0 = \frac{2m^2c^2\lambda^2}{h^2}$ d) $\lambda_0 = \lambda$

135. Figure shows the plot of the stopping potential versus the frequency of the light used in an experiment on photoelectric effect. The ratio h/e is



a) 10^{-15} V s^{-15} V s b) 2×10^{-15} V s c) 3×10^{-15} V s d) 4.14×10^{-15} V s

136. An electron of mass m_e and a proton of mass m_p are accelerated through the same potential difference. The ratio of the de Broglie wavelength associated with an electron to that associated with proton is

a) 1 b) m_p/m_e c) m_e/m_p d) $\sqrt{m_p/m_e}$

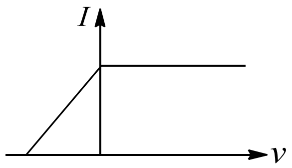
137. The resolving power of an electron microscope operated at 16 kV is R. The resolving power of the electron microscope when operated at 4 kV is

a) $R/4$ b) $R/2$ c) $4R$ d) $2R$

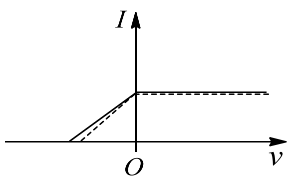
138. The light sensitive compound on most photographic films is silver bromide AgBr. A film is exposed when the light energy absorbed dissociates this molecule into its atoms. The energy of dissociates of AgBr is 10^5 J mol^{-1}. For a photon that is just able to dissociate a molecule of AgBr, the photon energy is

a) 1.04 eV b) 2.08 eV c) 3.12 eV d) 4.16 eV

139. A metal surface in an evacuated tube is illuminated with monochromatic light causing the emission of photoelectrons which are collected at an adjacent electrode. For a given intensity of light, the way in which the photocurrent I depends in the potential difference V between the electrodes is shown by approximate graph in Figure



If the experiment were repeated with light of twice the intensity but the same wavelength, which of the graphs below would best represent the new relation between I and V? (In these graphs, the result of the original experiment is indicated by a broken line)

a)


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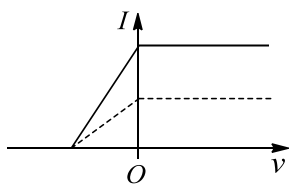

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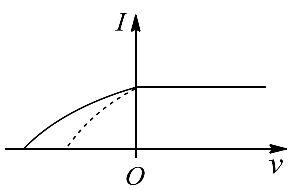
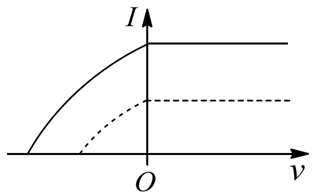


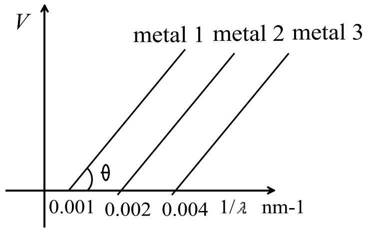
d)


Multiple Correct Answers Type

140. A particle of mass M at rest decays into two particles of masses m_1 and m_2 having non-zero velocities. The ratio of the de Broglie wavelengths of the particles λ_1/λ_2 is

a) m_1/m_2 b) m_2/m_1 c) 1.0 d) $\sqrt{m_2}/\sqrt{m_1}$

141. The graph between $1/\lambda$ and stopping potential (V) of three metals having work functions ϕ_1, ϕ_2 and ϕ_3 in an experiment of photo-electric effect is plotted as shown in the figure. Which of the following statement(s) is/are correct? [Here λ is the wavelength of the incident ray]



a) Ratio of work functions $\phi_1 : \phi_2 : \phi_3 = 1 : 2 : 4$
b) Ratio of work functions $\phi_1 : \phi_2 : \phi_3 = 4 : 2 : 1$
c) $tan\,\theta$ is directly proportional to hc/e, where h Plank's constant and c is the speed of light
d) The violet colour light can eject photoelectrons from metals 2 and 3

142. A collimated beam of light of flux density 3 k Wm^{-2} is incident normally on a 100 mm^2 completely absorbing screen. If P is the pressure exerted on the screen and Δp is the momentum transferred to the screen during a 1000 s interval, then

a) $P = 10^{-3}\ \mathrm{Nm}^{-2}$ b) $P = 10^{-4}\ \mathrm{Nm}^{-2}$ c) $\Delta p = 10^{-4}\ \mathrm{Kgms}^{-1}$ d) $\Delta p = 10^{-5}\ \mathrm{Kgms}^{-1}$

143. When a point light source of power W emitting monochromatic light of wavelength λ is kept at a distance a from a photo-sensitive surface of work function ϕ and area S, we will have

a) Number of photons striking the surface per unit time as $W\,\lambda S/4\,\pi hca^2$
b) The maximum energy of the emitted photoelectrons as $(1/\lambda)(hc - \lambda\phi)$
c) The stopping potential needed to stop the most energetic emitted photoelectrons as $(e/\lambda)(hc - \lambda\phi)$
d) Photo-emission only if λ lies in the range $0 \le \lambda \le (hc/\phi)$

144. Threshold wavelength of certain metal is λ_0. A radiation of wavelength $\lambda < \lambda_0$ is incident on the plate. Then, choose the correct statement from the following

a) Initially, electrons will come out from the plate
b) The ejected electrons experience retarding force due to development of positive charges on the plate
c) After some time, ejection of electrons stops
d) None of the above

145. When photons of energy 4.25 eV strike the surface of metal A, the ejected photoelectrons have maximum kinetic energy T_A and de Broglie wavelength λ_A. The maximum kinetic energy of photoelectrons liberated from another metal B by photons of energy 4.70 eV is $T_B = (T_A - 1.50)$ eV. If the de Broglie wavelength of these photoelectrons is $\lambda_B = 2\lambda_A$, then

a) The work function of A is 2.25 eV b) The work function of B is 4.20 ev
c) $T_A = 2.00$ eV d) $T_B = 2.75$ eV

146. Electric conduction takes place in a discharge tube due to movement of

a) Positive ions b) Negative ions c) Electrons d) Photons

147. A point source of light is taken away from the experimental setup of photoelectric effect. For this situation, mark out the correct statement(s)

a) Saturation photocurrent decreases
b) Saturation photocurrent increases
c) Stopping potential remains the same
d) Stopping potential increases

148. In a photoelectric experiment, the wavelength of the incident light is decreased from 6000 Å and 4000 Å.

While the intensity of radiations remains the same
a) The cut-off potential will decrease
b) The cut-off potential will increase
c) The photoelectric current will increase
d) The kinetic energy of the emitted electrons will increase

149. In Thomson's experiment, if the velocity of electron is greater than the ratio of electric field (E) and magnetic field ($ie, v > E/B$), then
a) The electron will reach the undeflected spot
b) The electron will not reach the undeflected spot
c) The electron will move to a spot above the undeflected position
d) The electron will move to a spot below the undeflected position

150. When a monochromatic point source of light is at a distance of 0.2 m from a photoelectric cell, the cut-off voltage and the saturation current are, respectively, 0.6 V and 18.0 mA. If the same source is placed 0.6 m away from the photoelectric cell, then
a) The stopping potential will be 0.2 V
b) The stopping potential will be 0.6 V
c) The saturation current will be 6.0 mA
d) The saturation current will be 2.0 mA

151. The shortest wavelength of X-rays emitted from an X-ray tube depends on
a) The current in the tube
b) The voltage applied to the tube
c) The nature of the gas in tube
d) The atomic number of the target material

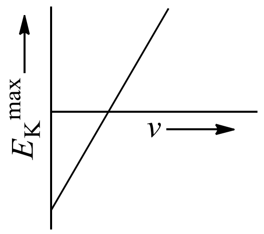
152. An X-ray tube is operating at 50 kV and 20 mA. The target material of the tube has a mass of 1.0 kg and specific heat 495 $kg^{-1}°C^{-1}$. One percent of the supplied electric power is converted into X-rays and the entire remaining energy goes into heating the target. Then
a) A suitable target material must have a high melting temperature
b) A suitable target material must have low thermal conductivity
c) The average trate of rise of temperature of target would be 2°C/s
d) The minimum wavelength of the X-rays emitted is about $0.25 \times 10^{-10} m$

153. When photons of energy hc/λ fall on a metal surface, photoelectrons are ejected from it. If the work function of the surface is hv_0, then
a) Maximum kinetic energy of the electron is $[(hc/\lambda) - hv_0]$
b) Maximum kinetic energy of the photoelectron is equal to (hc/λ)
c) Minimum KE of the photoelectron is zero
d) Minimum kinetic energy of the photoelectron is equal to hc/λ

154. The maximum kinetic energy of photoelectrons emitted from a surface when photons of energy 6 eV fall on it is 4 eV. The stopping potential in volts is
a) 2
b) 4
c) 6
d) 10

155. Photoelectric effect supports the quantum nature of light because
a) There is a minimum frequency of light below which no photoelectrons are emitted
b) The maximum KE of photoelectrons depends only on the frequency of light and not on its intensity
c) Even when the metal surface is faintly illuminated by light of wavelength less than the threshold wavelength, the photoelectrons leave the surface immediately
d) Electric charge of photoelectrons is quantized

156. The maximum kinetic energy of the emitted photoelectrons against frequency v of incident radiation is plotted as shown in Figure. This graph help us in determining the following physical quantities



a) Work function of the cathode-metal
b) Threshold frequency
c) Planck's constant
d) Change on an electron

157. The maximum KE of photoelectrons ejected from a photometer when it is irradiated of wavelength 400 nm is 1 eV. If the threshold energy of the surface is 0.9 eV
a) The maximum KE of photoelectrons when it is irradiated with 500 nm photons will be 0.42 eV
b) The maximum KE in case (a) will be 1.425 eV
c) The longest wavelength which will eject the photoelectrons from the surface is nearly 650 nm
d) Maximum KE will increases if the intensity of radiation is increased

158. The potential difference applied to a X-ray tube is increased. As a result, in the emitted radiation
a) The intensity wavelength increases
b) The minimum wavelength increases
c) The intensity remains unchanged
d) The minimum wavelength decreases

159. When barium is irradiated by a light of $\lambda = 4000$ Å, all the photoelectrons emitted are bent in a circle of radius 50 cm by a magnetic field of flux density 5.26×10^{-6} T acting perpendicular to plane of emission of photoelectrons. Then,
a) The kinetic energy of fastest photoelectron is 0.6 eV
b) Work function of the metal is 2.5 eV
c) The maximum velocity of photoelectron is 0.46×10^{6} ms^{-1}
d) The stopping potential for photoelectric effect is 0.6 V

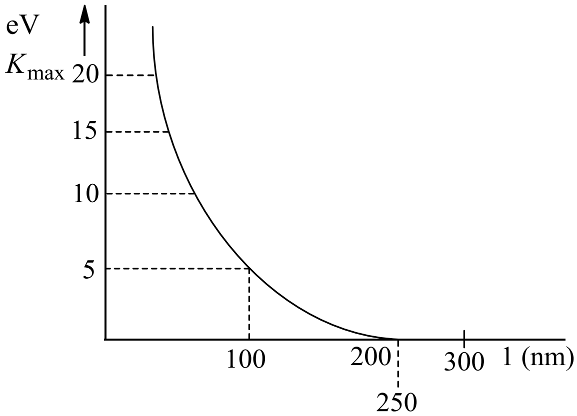
160. When photons of energy 4.25 eV strike the surface of a metal, the ejected photoelectrons have a maximum kinetic energy E_A eV and de-Broglie wavelengthλ_A. The maximum kinetic energy of photoelectrons liberated from another metal B by photons of energy 4.70 eV is $E_B = (E_A - 1.50)$eV. If the de-Broglie wavelength of these photoelectrons is $\lambda_B = 2\lambda_A$, then
a) The work function of A is 2.25 eV
b) The work function of B is 4.20 eV
c) $E_A = 2.0$ eV
d) $E_B = 2.75$ eV

161. Photoelectric effect supports quantum nature of light because
a) There is a minimum frequency of light below which no photoelectrons are emitted
b) The maximum kinetic energy of photoelectrons depends only on the frequency of light and not on its intensity
c) Even when the metal surface is faintly illuminated, the photoelectrons leave the surface immediately
d) Electric charge of the photoelectrons is quantized

162. The threshold wavelength for photoelectric emission from a material is 5200 Å. Photoelectrons will be emitted when this material is illuminated with monochromatic radiation from a
a) 50 W infrared lamp
b) 1 W infrared lamp
c) 50 W ultraviolet lamp
d) 1 W ultraviolet lamp

163. A laser used to weld detached retinas emits light with a wavelength of 652 nm in pulses that are 20.0 ms in duration. The average power during each is 0.6 W. Then,
a) The energy of each photon is 3.048×10^{-19} J
b) The energy content in each pulse is 12 mJ
c) The number of photons in each pulse is nearly 4×10^{15}
d) The energy of each photon is nearly 1. 9 eV

164. In a photoelectric effect experiment, the maximum kinetic energy of the ejected photoelectrons is measured for various wavelengths of the incident light. Figure shows a graph of this maximum kinetic energy $K_{\max}$ as a function of the wavelength λ of the light falling on the surface of the metal. Which of the following statement/s is/are correct?



a) Threshold frequency for the metal is 1.2×10^{15} m
b) Work function of the metal is 4.968 eV
c) Maximum kinetic energy of photoelectrons corresponding to light of wavelength 100 nm is nearly 7.4 eV
d) Photoelectric effect takes place with red light

165. When photon of energy 4.0 eV strikes the surface of a metal A, the ejected photoelectrons have maximum kinetic energy T_A eV and de-Broglie wavelength λ_A. The maximum kinetic energy of photoelectrons liberated from another metal B by photon of energy 4.50 eV is $T_B = (T_A - 150)$ eV. If the de-Broglie wavelength of these photoelectrons $\lambda_B = 2\lambda_A$, then
a) The work function of A is 1.50 eV
b) The work function of B is 4.0 eV
c) $T_A = 2.00$ eV
d) All of the above

166. When photon of energy 4.25 eV strike the surface of a metal A, the ejected photoelectrons have maximum kinetic energy T_A eV 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 $T_B = (T_A - 1.50)eV$. If the de-Broglie wavelength of these photoelectrons is $\lambda_B = 2\lambda_A$, then
a) The work function of A is 2.25 eV
b) The work function of B is 4.20 eV
c) $T_A = 2.00$ eV
d) $T_B = 2.75$ eV

167. The work function of a substance is 4.0 eV. The longest wavelength of light that can cause photoelectron emission from this substance is approximately
a) 540 nm
b) 400 nm
c) 310 nm
d) 220 nm

Assertion - Reasoning Type

This section contain(s) 0 questions numbered 168 to 167. Each question contains STATEMENT 1(Assertion) and STATEMENT 2(Reason). Each question has the 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

a) Statement 1 is True, Statement 2 is True; Statement 2 **is** correct explanation for Statement 1

b) Statement 1 is True, Statement 2 is True; Statement 2 **is not** correct explanation for Statement 1

c) Statement 1 is True, Statement 2 is False

d) Statement 1 is False, Statement 2 is True

168

Statement 1: In photoelectric effect, on increasing the intensity of light, both the number of electrons emitted and kinetic energy of each of them get increased but photoelectric current remains unchanged

Statement 2: The photoelectric current depends only on wavelength of light

169

Statement 1: X-rays are used for studying the structure of crystals

Statement 2: The distance between the atoms of crystals is of the order of wavelength of X-rays

170

Statement 1: Through light of a single frequency (monochromatic light) is incident on a metal, the energies of emitted photoelectrons are different

Statement 2: The energy of electrons just after they absorb photons incident on the metal surface may be lost in collision with other atoms in the metal before the electron is ejected out of the metal

171

Statement 1: The relative velocity of two photons travelling in opposite direction is the velocity of light.

Statement 2: The rest mass of photon is zero.

172

Statement 1: Soft and hard X-rays differ in frequency as well as velocity

Statement 2: The penetrating power of hard X-rays is more than the penetrating power of soft X-rays

173

Statement 1: The photoelectrons produced by a monochromatic light beam incident on a metal surface have a spread in their kinetic energies

Statement 2: The work function of the metal varies as a function of depth from the surface

174

Statement 1: If the frequency of the light incident on a metal surface is doubled, the maximum kinetic energy of emitted photoelectron also gets doubled.

Statement 2: Kinetic energy of practice is proportional to frequency.

175

Statement 1: If the accelerating potential in an X-ray tube is increased, the wavelengths of the characteristic X-rays do not change.

Statement 2: When an electron beam strikes the target in an X-ray tube, part of the kinetic energy is converted into X-ray energy.

176

Statement 1: X-rays cannot be diffracted by means of grating

Statement 2: Xrays do not obey Bragg's law

177

Statement 1: A tube light emits white light.

Statement 2: Emission of light in a tube takes place on a very high temperature.

178

Statement 1: X-rays travel with the speed of light

Statement 2: X-rays are electromagnetic rays

179

Statement 1: The energy (E) and momentum (p) of a photon are related by $p = E/c$

Statement 2: The photon behaves like a particle

180

Statement 1: When the speed of an electron increases its specific charge decreases

Statement 2: Specific charge is the ratio of the charge to mass

181

Statement 1: Photoelectric effect demonstrates the particle nature of light.

Statement 2: The number of photoelectrons is proportional to the frequency of light.

182

Statement 1: An electron is not deflected on passing through certain region of space. This observation confirms that there is no magnetic field in that region

Statement 2: The deflection of electron depend on angle between velocity of electron and direction of magnetic field

183

Statement 1: In photoemissive cell inert gas is used

Statement 2: Inert gas in the photoemissive cell gives greater current

184

Statement 1: Photoelectric effect can take place only with an electron bound in the atom.

Statement 2: Electron is a fermion whereas proton is a boson.

185

Statement 1: The phenomenon of X-ray production is basically inverse of photoelectric effect

Statement 2: X-rays are electromagnetic waves

186

Statement 1: In the process of photoelectric emission, all the emitted photoelectrons have the same kinetic energy

Statement 2: The photon transfer its whole energy to the electron of the atom in photoelectric effect

187

Statement 1: Penetrating power of X-rays increases with the increasing the wavelength

Statement 2: The penetrating power of X-rays increases with the frequency of X-rays

188

Statement 1: Electric conduction in gases is possible at normal pressure

Statement 2: The electric conduction in gases depends only upon the potential difference between the electrodes

189

Statement 1: An electric field is preferred in comparison to magnetic field for detecting the electron beam in a television picture tube

Statement 2: Electric field requires low voltage

190

Statement 1: Davisson-Germer experiment established the wave nature of electrons

Statement 2: If electrons have wave nature, they can interfere and show diffraction

191

Statement 1: If the accelerating potential of an electron is doubled then its velocity becomes 1.4 times.

Statement 2: It will move on a circular path with same velocity.

192

Statement 1: Stopping potential is a measure of KE of photoelectron.

Statement 2: $W = eV_s = \frac{1}{2} mv^2 = \text{KE}$

193

Statement 1: The de-Broglie wavelength of a molecule varies inversely as the square root of temperature.

Statement 2: The root mean square velocity of the molecule depends on the temperature.

194

Statement 1: A photon has no rest mass, yet it carries definite momentum.

Statement 2: Momentum of photon is due to energy hence its equivalent mass.

195

Statement 1: The de Broglie wavelength of a molecule (in a sample of ideal gas) varies inversely as the square root of absolute temperature

Statement 2: The de Broglie wavelength of a molecule (in a sample of ideal gas) depends on temperature

196

Statement 1: The specific charge of positive rays is not universal constant

Statement 2: The mass of ions varies with speed

197

Statement 1: A metallic surface is irradiated by a monochromatic light of frequency $v > v_0$ (the threshold frequency). The maximum kinetic energy and the stopping potential are

$K_{\max}$ and V_0 respectively. If the frequency incident on the surface is doubled, both the $K_{\max}$ and V_0 are also doubled

Statement 2: The maximum kinetic energy and the stopping potential of photoelectrons emitted from a surface are linearly dependent on the frequency of incident light

198

Statement 1: Work function of copper is greater than the work function of sodium, but both have same value of threshold frequency and threshold wavelength.

Statement 2: The frequency is inversely proportional to wavelength.

199

Statement 1: In Millikan's experiment for the determination of charge on an electron, oil drops of any size can be used

Statement 2: Millikan's experiment determines the charge on electron, by simply measuring the terminal velocity

200

Statement 1: Photocells are used in cinematography.

Statement 2: A photocell converts electrical energy into light energy

201

Statement 1: Light is produced in gases in the process of electric discharge through them at high pressure

Statement 2: At high pressure electrons of gaseous atoms collide and reach and excited state

202 A proton and an electron both have energy 50 eV

Statement 1: Both have different wavelengths

Statement 2: Wavelength depends on energy and not on mass

203

Statement 1: The specific charge for positive rays is a characteristic constant

Statement 2: The specific charge depends on charge and mass of positive ions present in positive rays

204

Statement 1: Separation of isotope is possible because of the difference in electron numbers of isotope

Statement 2: Isotope of an element can be separated by using a mass spectrometer

205

Statement 1: The threshold frequency of photoelectric effect supports the particle nature of sunlight

Statement 2: If frequency of incident light is less than the threshold frequency, electrons are not emitted from metal surface

206

Statement 1: Photosensitivity of a metal is high if its work function is small.

Statement 2: Work function $=hf_0$ where f_0 is the threshold frequency.

207

Statement 1: Standard optical diffraction can not be used for discriminating between different X-ray wavelengths

Statement 2: The grating spacing is not of the order of X-ray wavelengths

208

Statement 1: X-rays can penetrate through the flesh but not through the bones

Statement 2: The penetrating power of X-rays depends on voltage

209

Statement 1: Kinetic energy of photo electrons emitted by a photosensitive surface depends upon the intensity of incident photon

Statement 2: The ejection of electrons from metallic surface is possible with frequency of incident photon below the threshold frequency

210

Statement 1: The graph of stopping potential (V_s) $versus$ frequency (v) of incident radiation is a straight line nor passing through the origin.

Statement 2: According to Einstein's photoelectric equation the slope of the graph between V_s and v is $\frac{h}{e}$

211

Statement 1: When ultraviolet light is incident on a photocell, its stopping potential is V_0 and the maximum kinetic energy of the photoelectrons is $K_{\max}$. When the ultraviolet light is replaced by X-rays, both V_0 and $K_{\max}$ increase.

Statement 2: Photoelectrons are emitted with speeds ranging from zero to a maximum value because of the range of frequencies present in the incident light.

212

Statement 1: Intensity of X-rays can be controlled by adjusting the filament current and voltage

Statement 2: The intensity of X-rays does not depend on number of X-ray photons emitted per second from the target

213

Statement 1: Mass of moving photon varies inversely as the wavelength

Statement 2: Energy of the particle = Mass × (Speed of light)^2

214

Statement 1: 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 current before and after change are I_1 and I_2 all other conditions remaining unchanged (assuming $hv > W_2$) then $I_1 < I_2$.

Statement 2: In above case $I_1 = I_2$

Matrix-Match Type

This section contain(s) 0 question(s). Each question contains Statements given in 2 columns which have to be matched. Statements (A, B, C, D) in **columns I** have to be matched with Statements (p, q, r, s) in **columns II**.

215. Some laws/processes are given in Column I. Match these with the physical phenomena given in Column II

	Column-I		Column- II
(A)	Transition between two atomic energy levels	(p)	Characteristic X-rays
(B)	Electron emission from a material	(q)	Photoelectric effect
(C)	Moseley's law	(r)	Hydrogen spectrum
(D)	Change of photon energy into kinetic energy of electrons	(s)	β-decay

CODES :

	A	B	C	D
a)	P,r	q,s	p	q
b)	q,s	p,r	q	p
c)	p	q,s	p,r	q
d)	q	p	q,s	p,r

216. Related to photoelectric effect, in Column I, some physical quantities change while in Column II effects of these changes are given. Match the entries of column I with the entries of Column II

	Column-I		Column- II
(A)	Intensity of incident light changes	(p)	$K_{\max}$ of emitted photoelectrons changes
(B)	Frequency of incident light changes	(q)	Stopping potential changes
(C)	Target material changes	(r)	Saturation current changes
(D)	Potential difference between the emitter and collector changes	(s)	Time delay in emission of photoelectrons changes

CODES :

	A	B	C	D
a)	q	r	s	p
b)	r	s	p	q
c)	r	p,q	p,q	s
d)	p	q	r	s

217. In Column I, the nature of light is given and in Column II the information about the photons are mentioned. Match the entries of Column I with the entries of Column II

	Column-I		Column- II
(A)	A bichromatic light source	(p)	Few photons have same energy and momenta
(B)	A point source of white light emitting light uniformly in all directions	(q)	Few photons have different energy and different momenta

(C) A point source of monochromatic light emitting light uniformly in all directions
(D) Laser light source

(r) Few photons have same energy and different momenta
(s) Few photons have different energy and same momenta

CODES :

	A	B	C	D
a)	P,q,r,s	p,q,r,s	p,r	p
b)	p,q,r,s	p,r	p	p,q,r,s
c)	p,s	r,s	p,q	q,r
d)	r,s	p,q	q,r	p,s

218. With respect to photoelectric effect experiment, match the entries of Column I with the entries of Column II

Column-I

(A) If f (frequency) is increased keeping I (intensity) and ϕ (work function) constant
(B) If I is increased keeping f and ϕ constant
(C) If the distance between anode and cathode increase
(D) If ϕ is decreased keeping f and I constnat

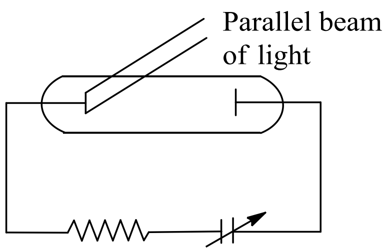
Column- II

(p) Stopping potential increases
(q) Saturation photocurrent increases
(r) Maximum KE of the photoelectrons increases
(s) Stopping potential remains the same

CODES :

	A	B	C	D
a)	P,r	q,s	s	p,r
b)	q,s	s	p,r	p,r
c)	p,q	r,s	r,s	q,s
d)	r,s	r,s	q,s	p,q

219. In the shown experimental setup to study photoelectric effect, two conducting electrodes in an evacuated glass-tube as shown. A parallel beam of monochromatic light falls on photosensitive electrode. The emf of battery shown is high enough such that all photoelectrons ejected from left electrode will reach the right electrode. Under initial conditions, photoelectrons are emitted. As charges are made in each situation of Column I. Match the statement in Column I with results in Column II



Column-I

(A) If frequency of incident light is increased keeping its intensity constant

Column- II

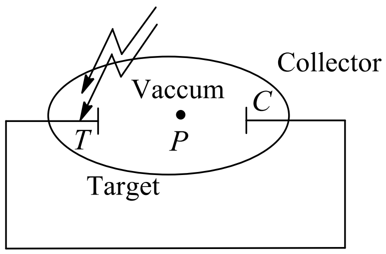
(p) Magnitude of stopping potential will increase

(B)	If frequency of incident light is increased and its intensity is decreased	(q)	Current through the circuit may stop
(C)	If work function of photon sensitive electrode is increased	(r)	Maximum kinetic energy of ejected photoelectrons will increase
(D)	If intensity of incident light is increased keeping its frequency constant	(s)	Saturation current will increase

CODES :

	A	B	C	D
a)	P,q	r,s	p,s	q,r
b)	r,s	p,s	q,r	p,q
c)	p,r	q	s	p,r
d)	p,r	p,r	q	s

220. In a photoelectric experimental arrangement, light of frequency f is incident on a metal target whose work function is $\phi = hf/3$ as shown. In Column I, KE of photoelectron is mentioned at various locations/instants and in Column II, the corresponding values. Match the entries of Column I with the entries of Column II



	Column-I		Column- II
(A)	Maximum KE of photoelectrons just after emission from target	(p)	Zero
(B)	KE of photoelectrons just after emission from target	(q)	$hf/3$
(C)	KE of photoelectron when they are halfway between the target and collector	(r)	$hf/2$
(D)	KE of photoelectrons as they reach the collector	(s)	$2hf/3$

CODES :

	A	B	C	D
a)	P,q,r,s	q,r,s	p,r,s	s
b)	s	p,q,r,s	q,r,s	p,r,s
c)	q,r,s	p,r,s	s	p,q,r,s
d)	p,r,s	s	p,q,r,s	q,r,s

Linked Comprehension Type

This section contain(s) 27 paragraph(s) and based upon each paragraph, multiple choice questions have to be answered. Each question has atleast 4 choices (a), (b), (c) and (d) out of which **ONLY ONE** is correct.

Paragraph for Question Nos. 221 to -221

According to Einstein, when a photon or light of frequency v or wavelength λ is incident o photosensitive metal surface of work function ϕ_0, where $\phi_0 < hv$ (here h is Planck's constant), then the emission of photoelectrons takes place. The maximum kinetic energy of the emitted photoelectrons is given by $K_{\max} = hv - \phi_0$. If the frequency of the incident light is v_0 (called threshold frequency), the photoelectrons are emitted from metal without any kinetic energy. So $hv_0 = \phi_0$

221. Stopping potential of emitted photoelectron is given by

a) $\frac{hv - \phi_0}{e}$ b) $hv - \phi_0$ c) $\frac{hv}{e}$ d) $\frac{\phi_0 + hv}{e}$

Paragraph for Question Nos. 222 to - 222

According to de-Broglie, a moving material particle exhibits dual nature (*ie*, a particle as well as a wave). He also predicted that a wave is associated with every moving material particle (which controls the particle) called matter wave and its wavelength is called de-Broglie wavelength given by

$\lambda = h/mv$

Where h is Planck's constant, m is the mass of the particle moving with velocity v.

The existence of matter waves was firstly experimentally verified by Davisson and Germer using slow moving electrons which were accelerated with moderate accelerating potential.

222. An electron is accelerated under a potential difference of 64 V, the de-Broglie wavelength associated with electron is (use charge of electron 1.6×10^{-19}C, mass of electron 9.1×10^{-31}kg; $h = 6.623 \times 10^{-34}$ J-s).

a) 1.53 Å b) 2.53 Å c) 3.35 Å d) 4.54 Å

Paragraph for Question Nos. 223 to - 223

Photoelectric threshold of silver is $\lambda = 3800$ Å. Ultraviolet light of $\lambda = 2600$ Å is incident on silver surface. (Mass of the electron 9.11×10^{-31} kg)

223. Calculate the value of work function in eV

a) 1.77 b) 3.27 c) 5.69 d) 2.32

Paragraph for Question Nos. 224 to - 224

A 100 W point source emits monochromatic light of wavelength 6000 Å

224. Calculate the total number of photons emitted by the source per second

a) 5×10^{20} b) 8×10^{20} c) 6×10^{21} d) 3×10^{20}

Paragraph for Question Nos. 225 to - 225

A metallic surface is illuminated alternatively with lights of wavelength 3000 Å and 6000 Å. It is observed that the maximum speeds of the photoelectrons under these illuminations are in the ratio 3:1

225. The work function of the metal is
a) 1.45 eV
b) 2.26 eV
c) 1.23 eV
d) 3.4 eV

Paragraph for Question Nos. 226 to - 226

A helium-neon laser has a power output of 1 mW of light of wavelength 632.8 nm

226. Calculate the energy of each photon in electron volt
a) 2.5
b) 1.96
c) 0.53
d) 3.3

Paragraph for Question Nos. 227 to - 227

Photoelectrons are ejected from a surface when light of wavelength $\lambda_1 = 550$ nm is incident on it. The stopping potential for such electrons is $\lambda_{s1} = 0.19$ V. Suppose that radiation of wavelength $\lambda_2 = 190$ nm is incident on the surface

227. Calculate the stopping potential V_{s2}
a) 4.47
b) 3.16
c) 2.76
d) 5.28

Paragraph for Question Nos. 228 to - 228

In a photoelectric effect experiment, a metallic surface of work function 2.2 eV is illuminated with a light of wavelength 400 nm. Assume that an electron makes two collisions before being emitted and in each collision 10% additional energy is lost

228. Find the kinetic energy of this electron as it comes out of the metal
a) 0.46 eV
b) 0.31 eV
c) 0.23 eV
d) None of these

Paragraph for Question Nos. 229 to - 229

In a photoelectric setup, a point source of light of power 3.2×10^{-3} W emits monoenergetic photons of energy of energy 5.0 eV. The source is located at a distance of 0.8 m from the center of a stationary metallic sphere of work function 3.0 eV and of radius 8.0×10^{-3} m. The efficiency of photoelectron emission is 1 for every 10^6 incident photons. Assume that the sphere is isolated and initially neutral and that photoelectrons are instantaneously swept away after emission

229. Calculate the number of photoelectrons emitted per second
a) 10^3
b) 10^4
c) 5×10^4
d) 10^5

Paragraph for Question Nos. 230 to - 230

The incident intensity of a horizontal surface at sea level from sun is about 1 kW m^{-2}

230. Assuming that 50 per cent of this intensity is reflected and 50 per cent is absorbed, determined the radiation pressure on this horizontal surface (in pascals)

a) 8.2×10^{-2} b) 5×10^{-6} c) 3×10^{-5} d) 6×10^{-5}

Paragraph for Question Nos. 231 to - 231

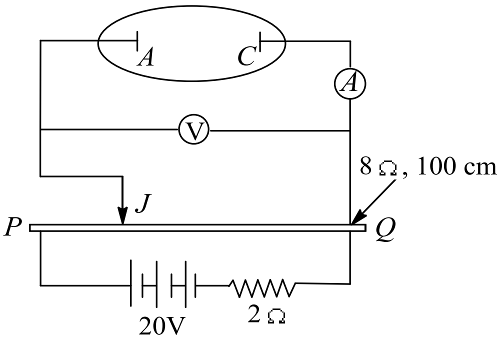
Light of intensity I falls along the axis on a perfectly reflecting right circular cone having semi-vertical angle θ and base radius R. If E is the energy of one photon and c is the speed of light, then find

231. The number of photons hitting the cone per second

a) $\pi R^2 I/2E$ b) $2\pi R^2 I/E$ c) $\pi R^2 I/4E$ d) $\pi R^2 I/E$

Paragraph for Question Nos. 232 to - 232

An experimental setup of verification of photoelectric effect is shown in figure. The voltage across the electrodes is measured with the help of an ideal voltmeter, and which can be varied by moving jockey 'J' on the potentiometer wire. The battery used in potentiometer circuit is of 20 V and its internal resistance is 2 Ω. The resistance of 100 cm long potentiometer wire is 8 Ω



The photocurrent is measured with the help of an ideal ammeter. Two plates of potassium oxide of area 50 cm^2 at separation 0.5 mm are used in the vacuum tube. Photocurrent in the circuit is very small, so we can treat the potentiometer circuit as an independent circuit

The wavelength of various colours is as follows:

	1	2	3	4	5	6
Light	**Violet**	**Blue**	**Green**	**Yellow**	**Orange**	**Red**
λ in Å	4000 – 5000	4500 – 5000	5000 – 5500	55000 – 6000	6000 – 6500	6500 – 7000

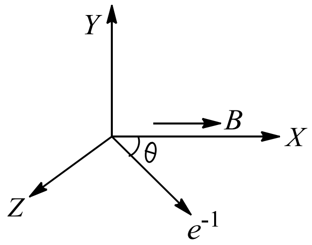
232. Calculate the number of electrons that appear on the surface of the cathode plate, when the jockey is connected at the end 'P' of the potentiometer wire. Assume that no radiation is falling on the plates

a) 8.85×10^6 b) 11.0625×10^9 c) 8.85×10^9 d) 0

Paragraph for Question Nos. 233 to - 233

Light having photon energy hv is incident on a metallic plate having work function ϕ to eject the electrons. The most energetic electrons are then allowed to enter in a region of uniform magnetic field B as shown in figure. The electrons are projected in $X - Z$ plane making an angle θ with X-axis and magnetic field is $\vec{B} = B_0\hat{\imath}$ along X-

axis



Maximum pitch of the helix described by an electron is found to be p. Take mass of electron as m and charge as q

Based on above information, answer the following questions:

233. The correct relation between p and B_0 is

a) $qpB_0 = 2\pi \cos\theta \sqrt{2(hv-\phi)m}$ b) $qpB_0 = 2\pi \cos\theta \sqrt{\frac{2(hv-\phi)}{m}}$

c) $pqB_0 = 2\pi\sqrt{2(hv-\phi)m}$ d) $p = \frac{2\pi}{qB_0}\sqrt{hv-\phi}$

Paragraph for Question Nos. 234 to - 234

When light of sufficiently high frequency is incident on a metallic surface, electrons are emitted from the metallic surface. This phenomenon is called photoelectric emission. Kinetic energy of the emitted photoelectrons depends on the wavelength of incident light and is independent of the intensity of light. Number of emitted photoelectrons depends on intensity. $(hv-\phi)$ is the maximum kinetic energy of emitted photoelectrons (where ϕ is the work function of metallic surface). Reverse effect of photo emission produces X-ray, X-ray is not deflected by electric and magnetic fields, wavelength of a continuous X-ray depends on potential difference across the tube. Wavelength of characteristic X-ray depends on the atomic number

234. If frequency $(v > v_0)$ of incident light becomes n times the initial frequency (v), then KE of the emitted photoelectrons becomes (v_0 threshold frequency)

a) n times of the initial kinetic energy
b) More than n times of the initial kinetic energy
c) Less than n times of the initial kinetic energy
d) Kinetic energy of the emitted photoelectrons remains unchanged

Paragraph for Question Nos. 235 to - 235

The energy received from the Sun by earth and surrounding atmosphere is 2 cal cm^{-2} min^{-1} on a surface normal to the rays of sun

235. What is total energy received, in joule, by the Earth and its atmosphere

a) 10.645×10^{18} J min^{-1} b) 10.645×10^{15} J min^{-1}

c) 8.645×10^{17} J min^{-1} d) 9.645×10^{14} J min^{-1}

Paragraph for Question Nos. 236 to - 236

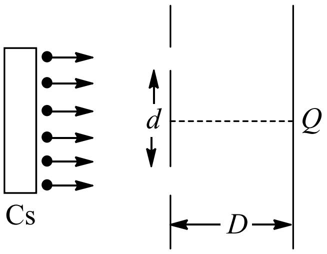
When a high frequency electromagnetic radiation is incident on a metallic surface, electrons are emitted from

the surface. Energy of emitted photoelectrons depends only on the frequency of incident electromagnetic radiation and number of emitted electrons depends only on the intensity of incident light
Einstein photoelectric equation [$K_{\max} = h\nu - \phi$] correctly explains the PE, where ν =frequency of incident light and ϕ =work function

236. Light of wavelength 3300 is incident on two metals A and B, whose work functions are 4 eV and 2 eV, respectively. Then
    a) A will emit photoelectrons but B will not
    b) B will emit photoelectrons, but A will not
    c) Both A and B will not emit photoelectrons
    d) Neither A nor B will emit photoelectrons

Paragraph for Question Nos. 237 to - 237

A Cs plate is irradiated with a light of wavelength $\lambda = hc/\phi, \phi$ being the work function of the plate, h the Planck's constant, and c the velocity of light in vacuum. Assume all the photoelectrons are moving perpendicular to the plate towards a YDSE setup when accelerated through a potential difference V. Take charge on a proton= e and mass of an electron = m



Read the paragraph carefully and answer the following questions:

237. The fringe width due to the electron beam is
    a) $\lambda D/d$ b) $\lambda D/2d$ c) $hD/(d\sqrt{2emV})$ d) None of these

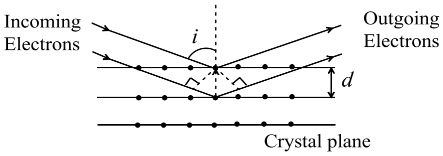
Paragraph for Question Nos. 238 to - 238

A pushed dye laser emits light of wavelength 585 nm. Because this wavelength is strongly absorbed by the haemo- globin in the blood, the method is especially effective for removing various types of blemishes due to blood. To get a reasonable estimate of the power required for such laser surgery, we can model the blood as having the same specific heat and heat of vaporization as water
[$S = 4.2 \times 10^3$ J (kg K)$^{-1}$, $L = 2.25 \times 10^6$ J kg]

238. Suppose that each pulse must remove 2 μg of blood by evaporating it starting at 30°C. The energy that each pulse must deliver to the blemish is nearly
    a) 5.1 J   b) 5.1 mJ   c) 5.1 μJ   d) 5.1 kJ

Paragraph for Question Nos. 239 to - 239

Wave property of electrons implies that they will show diffraction effects. Davisson and Germer demonstrated this by diffracting electrons from crystals. The law governing the diffraction from a crystal is obtained by requiring that electron waves reflected from the planes of atoms in a crystal interfere constructively (see figure)



239. If a strong diffraction peak is observed when electrons are incident at an angle $'i'$ from the normal to the crystal planes with distance $'d'$ between them (see figure), de Broglie wavelength λ_{dB} of electrons can be calculated by the relationship (n is an integer)
a) $2d \cos i = n\lambda_{dB}$ b) $2d \sin i = n\lambda_{dB}$ c) $d \cos i = n\lambda_{dB}$ d) $d \sin i = n\lambda_{dB}$

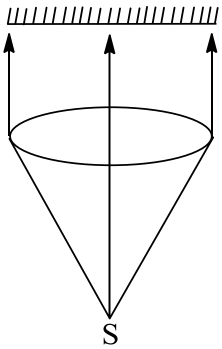
Paragraph for Question Nos. 240 to - 240

A dense collection of equal number of electrons and positive ions is called neutral plasma. Certain solids containing fixed positive ions surrounded by free electrons can be treated as neutral plasma. Let $'N'$ be the number density of free electrons, each of mass 'm'. When the electrons are subjected to an electric field, they are displaced relatively away from the heavy positive ions. If the electric filed becomes zero, the electrons begin to oscillate about the positive ions with a natural angular frequency $'\omega_p'$, which is called the plasma frequency. To sustain the oscillations, a time varying electric fields need to be applied that has an angular frequency ω, where a part of the energy is absorbed and a part of it is reflected. As ω approaches ω_p all the free electrons are set to resonance together and all the energy is reflected. This is the explanation of high reflectivity of metals

240. Taking the electronic charge as $'e'$ and the permittivity as $'\epsilon_0'$, use dimensional analysis to determine the correct expression for ω_p
a) $\sqrt{\frac{Ne}{m\epsilon_0}}$ b) $\sqrt{\frac{m\epsilon_0}{Ne}}$ c) $\sqrt{\frac{Ne^2}{m\epsilon_0}}$ d) $\sqrt{\frac{m\epsilon_0}{Ne^2}}$

Integer Answer Type

241. A totally reflecting, small plane mirror placed horizontally faces a parallel beam of light as shown in the figure. The mass of the mirror is 20 g. Assume that there is no absorption in the lens and that 30% of the light emitted by the source goes through the lens. Find the power (in $\times 10^8$ W) of the source needed to support the weight of the mirror. Take $g = 10 \text{ m/s}^2$



242. A monochromatic sources of light operating at 200 W emits 4×10^{20} photons per second. Find the wavelength of the light (in $\times 10^{-7}$ m)
243. A silver sphere of radius 1 cm and work function 4.7 eV is suspended from an insulating thread in free-space. It is under continuous illumination of 200 nm wavelength light. As photoelectrons are emitted, the sphere gets charged and acquires a potential. The maximum number of photoelectrons emitted from the sphere is $A \times 10^z$ (where $1 < A < 10$). The value of $'Z'$ is

244. A silver ball of radius 4.8 cm is suspended by a thread in a vacuum chamber. Ultraviolet light of wavelength 200 nm is incident on the ball for some time during which a total light energy of 1.0×10^{-7} J falls on the surface. Assuming that on the average, one photon out of ten thousand photons is able to eject a photoelectron, find the electric potential (in $\times 10^{1}$ V) at the surface of the ball assuming zero potential at infinity

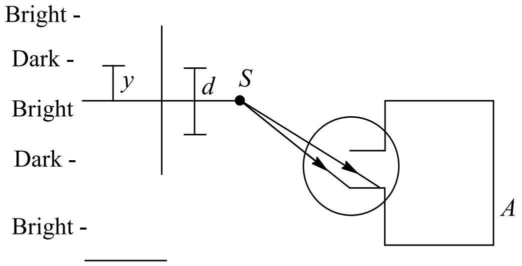
245. The de Broglie wavelength of an electron moving with a velocity of 1.5×10^{8} ms^{-1} is equal to that of a photon. Find the ratio of the kinetic energy of the photon to that of the electron

246. A proton is fired from very far away towards a nucleus with charge $Q = 120\,e$, where e is the electronic charge. It makes a closest approach of 10 fm to the nucleus. The de Broglie wavelength (in units of fm) of the proton at its start is :
(take the proton mass, $m_p = (5/3) \times 10^{-27} kg$:
$h/e = 4.2 \times 10^{-15} J.s/C; \dfrac{1}{4\pi\varepsilon_0} = 9 \times 10^{9} m/F; 1fm = 10^{-15} m$)

247. A parallel beam of monochromatic light of wavelength 663 nm is incident on a totally reflecting plane mirror. The angle of incidence is 60° and the number of photons striking the mirror per second is 1.0×10^{19}. Calculate the force exerted by light beam on the mirror. (in 10^{-8} N)

248. The radius of an α-particle moving in a circle in a constant magnetic field is half of the radius of an electron moving in circular path in the same filed. The de Broglie wavelength of α-particle is n times that of the electron. Find n (an integer)

249. In the arrangement shown in the figure, $y = 1.0$ mm, $d = 0.24$ mm and $D = 1.2$ m. The work function of the material of the emitter is 2.2 eV. Find the stopping potential V needed to stop the photocurrent (in $\times 10^{1}$ V)



250. An element of atomic number 9 emits K_α X-ray of wavelength λ. Find the atomic number of the element which emits K_α X-ray of wavelength 4λ

: ANSWER KEY :

1)	b	2)	b	3)	c	4)	d		2)	a,c	3)	b,d	4)	a,b,d	
5)	c	6)	c	7)	b	8)	a	5)	a,b	6)	a,b,c	7)	a,b,c	8)	
9)	d	10)	c	11)	c	12)	c		a,c						
13)	d	14)	b	15)	d	16)	c	9)	b,d	10)	b,d	11)	b,d	12)	
17)	d	18)	c	19)	b	20)	b		b,d						
21)	c	22)	b	23)	c	24)	a	13)	a,c,d	14)	a,c	15)	b	16)	
25)	c	26)	c	27)	b	28)	d		a,b,c						
29)	a	30)	c	31)	b	32)	b	17)	a,b,c	18)	a,c	19)	c,d	20)	
33)	c	34)	c	35)	c	36)	c		a,b,c,d						
37)	c	38)	b	39)	a	40)	c	21)	a,b,c	22)	a,b,c	23)	c,d	24)	
41)	c	42)	d	43)	d	44)	a		a,b,c,d						
45)	d	46)	a	47)	a	48)	b	25)	a,b,c	26)	b,c	27)	a,b,c	28)	c
49)	b	50)	b	51)	d	52)	a	1)	d	2)	a	3)	a	4)	b
53)	a	54)	c	55)	b	56)	b	5)	e	6)	c	7)	d	8)	b
57)	a	58)	c	59)	c	60)	a	9)	c	10)	c	11)	a	12)	a
61)	d	62)	d	63)	b	64)	b	13)	b	14)	c	15)	e	16)	a
65)	b	66)	a	67)	d	68)	a	17)	c	18)	b	19)	e	20)	e
69)	c	70)	c	71)	a	72)	c	21)	d	22)	d	23)	a	24)	c
73)	c	74)	c	75)	d	76)	d	25)	c	26)	b	27)	a	28)	b
77)	c	78)	a	79)	d	80)	b	29)	b	30)	d	31)	d	32)	e
81)	c	82)	b	83)	b	84)	c	33)	b	34)	d	35)	c	36)	b
85)	d	86)	c	87)	a	88)	a	37)	e	38)	b	39)	b	40)	a
89)	b	90)	a	91)	c	92)	d	41)	b	42)	d	43)	a	44)	c
93)	a	94)	b	95)	b	96)	d	45)	c	46)	b	47)	d	1)	a
97)	d	98)	b	99)	c	100)	b		2)	c	3)	a	4)	a	
101)	a	102)	a	103)	c	104)	b	5)	d	6)	b	1)	a	2)	a
105)	a	106)	a	107)	c	108)	a		3)	b	4)	d			
109)	a	110)	b	111)	a	112)	b	5)	c	6)	b	7)	a	8)	d
113)	a	114)	a	115)	c	116)	a	9)	d	10)	b	11)	d	12)	c
117)	a	118)	d	119)	b	120)	a	13)	a	14)	b	15)	a	16)	b
121)	b	122)	b	123)	c	124)	b	17)	c	18)	b	19)	a	20)	c
125)	d	126)	d	127)	a	128)	a	1)	1	2)	4	3)	7	4)	3
129)	b	130)	d	131)	c	132)	a	5)	4	6)	7	7)	1	8)	1
133)	b	134)	a	135)	d	136)	d	9)	9	10)	5				
137)	b	138)	a	139)	b	1)	c								

: HINTS AND SOLUTIONS :

1 **(b)**

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

$\frac{hc}{\lambda_{\min}} = \text{eV}$

$\lambda \times \frac{hc}{\lambda_{\min}} = \frac{h}{\sqrt{2meV}}\text{eV}$ or $\frac{\lambda}{\lambda_{\min}} \propto \sqrt{V}$

2 **(b)**

$hv_1 - hv_0 = \frac{1}{2}mv_1^2$

$hv_2 - hv_0 = \frac{1}{2}mv_2^2$

$\therefore h(v_1 - v_2) = \frac{1}{2}m(v_1^2 - v_2^2)$ [$\because v_1 = f_1$ and $v_2 = f_2$]

$\therefore v_1^2 - v_2^2 = \frac{2h}{m}(f_1 - f_2)$

3 **(c)**

Photons have momentum ($p = h/\lambda$) which they carry away; the spacecraft will acquire momentum in the opposite direction according to law of conservation of momentum

No. of photons per second from laser $= n$

Then, from energy considerations,

$0.5 \times 10^{-3} = nh\left(\frac{c}{\lambda}\right)$

$n = (0.5 \times 10^{-3})\lambda/(ch)$

Rate of change of momentum of spacecraft

$= np = n\frac{h}{\lambda} = (0.5 \times 10^{-3})\frac{\lambda}{ch}\left(\frac{h}{\lambda}\right) = \frac{0.5 \times 10^{-3}}{c}$

From Newton's second law, $\frac{nh}{\lambda} = ma$

$1000a = \frac{0.5 \times 10^{-3}}{3.00 \times 10^8} = \frac{1}{6} \times 10^{-11}$

$t = \frac{v}{a} = \frac{1000}{\left(\frac{1}{1000}\right) \times \frac{1}{6} \times 10^{-11}}\text{s} = 6 \times 10^{17}\text{ s}$

4 **(d)**

$\lambda_{\min} = \frac{hc}{eV}$ or $\lambda_{\min} \propto \frac{1}{V}$ On increasing potential, $\lambda_{\min}$ decreases

5 **(c)**

Applied voltage must be greater than binding enegy

6 **(c)**

$\frac{hc}{\lambda_{\max}} = 3 \times 1.6 \times 10^{-19}\text{ J}$

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

or $\lambda_{\max} = 4.125 \times 10^{-7}\text{ m}$

7 **(b)**

Velocity at highest point $= u\sin\theta$

$\therefore \lambda_D = \frac{h}{mu\sin\theta}$

(since θ is angle w.r.t. vertical)

8 **(a)**

$mvr = n\frac{h}{2\pi}$

$= 2\left(\frac{h}{2\pi}\right)$ $(n = 2)$

or $mvr = \frac{h}{\pi}$

$\therefore \lambda = \frac{h}{mv} =$ de Broglie wavelength

9 **(d)**

By photoelectric equation $= \frac{1}{2}mv^2 = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$

where λ is the wavelength of incident radiation and λ_0 is the threshold wavelength

$\frac{1}{2}m(2v)^2 = hc\left(\frac{1}{\lambda'} - \frac{1}{\lambda_0}\right)$

Solving for λ', we get $\lambda' = 300$ nm

10 **(c)**

Consider energy conservation and concept of impulse

11 **(c)**

$I \propto 1/d^2$

When source is placed 2 m away, then $I' = (I/4)$.

The number of electrons emitted ∝ intensity.

Hence, the number of emitted electrons is reduced to one-fourth

12 **(c)**

When intensity is increased from I_0 to $4I_0$. i.e., four times, then the saturation current increases by a factor of 4, i.e., the saturation current becomes

$= 4 \times (0.40 \times 10^{-6})\text{A}$

13 **(d)**

The electrons ejected with maximum speed $V_{\max}$ are stopped by electric field $E = 4N/C$ after travelling a distance $d = 1$ m

$\frac{1}{2}mv_{\max}^2 = eEd = 4\text{ eV}$

The energy of incident photon $= \frac{1240}{200} = 6.2$ eV

From equation of photon electric effect

$\frac{1}{2}mv_{\max}^2 = hv - \phi_0$

$\therefore \phi_0 = 6.2 - 4 = 2.2$ eV

14 **(b)**

The momentum of photon $= h/\lambda$

If n is the number of photons falling per second on the plate, then total momentum per second of the incident photons is

$$P = n \times \frac{h}{\lambda}$$

Since the plate is blackened, all photons are absorbed by it

$$\frac{\Delta P}{\Delta t} = n\frac{h}{\lambda}$$

Since $F = \frac{\Delta P}{\Delta t} = n\frac{h}{\lambda}$

$$\therefore n = \frac{F\lambda}{h}$$

$$n = \frac{6.62 \times 10^{-5} \times 5 \times 10^{-7}}{6.62 \times 10^{-34}} = 5 \times 10^{22}$$

15 **(d)**

Magnetic force experienced by a charged particle in a magnetic field is given by

$F_B = q\vec{v} \times \vec{B} = qvB \sin\theta$

In our case, $F_B = qvB$ [as $\theta = 90°$]

Hence, $Bqv = \frac{mv^2}{r} \Rightarrow mv = qBr$

The de Broglie wavelength,

$$\lambda = \frac{h}{mv} = \frac{h}{qBr}$$

$$\frac{\lambda_{\alpha-\text{particle}}}{\lambda_{\text{proton}}} = \frac{q_p r_p}{q_\alpha r_\alpha}$$

Since $\frac{r_\alpha}{r_p} = 1$ and $\frac{q_\alpha}{q_p} = 2$

$$\Rightarrow \frac{\lambda_\alpha}{\lambda_p} = \frac{1}{2}$$

16 **(c)**

In the first case,

$$\frac{1}{2}mv_{\max}^2 = 2hv_0 - hv_0 = hv_0$$

In the second case,

$$\frac{1}{2}mv_{\max}^2 = 5hv_0 - hv_0 = 4hv_0$$

Clearly, $v_{\max}$ is doubled

17 **(d)**

Momentum of photon of green light,

$$p = \frac{h}{\lambda} = \frac{6.626 \times 10^{-34}}{505 \times 10^{-9}} 1.3 \times 10^{-27} \text{ kg ms}^{-1}$$

Velocity of bacterium,

$$v = \frac{p}{m} = \frac{1.3 \times 10^{-27}}{9.5 \times 10^{-15}}$$

$= 1.368 \times 10^{-13} \text{ ms}^{-1}$

18 **(c)**

The ratio of electric force to magnetic force is:

$$\frac{F_e}{F_B} = \frac{qE}{qvB} = \frac{3 \times 10^6}{2.4 \times 10^6 \times 1.5} = \frac{5}{6}$$

Now, magnetic force on beta particles acts downward, whereas electric force acts upward and both are in the plane of diagram. But since magnetic force is larger, so beta particles are deflected downward

20 **(b)**

$\frac{\lambda_1}{\lambda_2} = \frac{\frac{h}{\sqrt{2mE}}}{\frac{hc}{E}}$ or $\frac{\lambda_1}{\lambda_2} \propto E^{1/2}$

22 **(b)**

The maximum KE of the photoelectron is given by

$$\left(\frac{1}{2}mv^2\right)_{\max} = hv - W$$

Now, $v = \frac{c}{\lambda}$ and $\left(\frac{1}{2}mv^2\right) = eV$

$\therefore eV = \frac{hc}{\lambda} - W$ or $V = \left(\frac{hc}{e}\right)\frac{1}{\lambda} - \frac{W}{e}$

Since V is represented along y-axis and $(1/\lambda)$ along x-axis, the above equation represents a straight line

Slope of straight line $= hc/e$

Intercept of straight line $= -(W/e)$

23 **(c)**

$$\frac{hc}{\lambda} = E + \phi_0$$

$$\frac{hc}{\lambda'} = 2E + \phi_0$$

Dividing, we get $\frac{\lambda'}{\lambda} = \left(\frac{E+\phi_0}{2E+\phi_0}\right)$ or $\frac{\lambda'}{\lambda} < 1$

$\therefore \lambda' < \lambda$ or $\lambda > \lambda'$ (i)

Also, $\frac{\lambda'}{\lambda} = \frac{1}{2}\left[\frac{E+\phi_0}{E+\frac{\phi_0}{2}}\right]$

or $\frac{\lambda'}{\lambda} > \frac{1}{2}$ or $\lambda' > \frac{\lambda}{2}$ (ii)

It follows from Eqs. (i) and (ii) that

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

24 **(a)**

$hv = 5 \text{ eV} + 2.2 \text{ eV} = 7.2 \text{ eV}$

$$7.2 = \frac{12375}{\lambda(\text{ in Å})}$$

or $\lambda\,(\text{in Å}) = \frac{12375}{7.2} \approx 1719$

25 **(c)**

Orbital angular momentum $= \frac{nh}{2\pi}$ for H-atom

Therefore, minimum value of $L = h/2\pi$ (for $n = 1$)

26 **(c)**

$$\lambda \propto \frac{1}{V} \text{ and } V \propto \sqrt{T}$$

27 **(b)**

The maximum KE of the photoelectron is given by

$$\left(\frac{1}{2}mv^2\right)_{\max} = hv - W$$

Now, $v = \frac{c}{\lambda}$ and $\left(\frac{1}{2}mv^2\right) = eV$

$\therefore eV = \frac{hc}{\lambda} - W$

or $V = \left(\frac{hc}{e}\right)\frac{1}{\lambda} - \frac{W}{e}$

Slope of straight line $= hc/e$

Intercept of straight line $= -(W/e)$

28 **(d)**

$$\frac{1}{2}mv_{\max}^2 = \frac{hc}{\lambda} - \phi_0$$

$$\frac{1}{2}mv_{\max}^2 = \frac{12375 \text{ eV}}{3000} - 1 \text{ eV}$$

$$\frac{1}{2}mv_{\max}^2 = 3.125 \times 1.6 \times 10^{-19}$$

$$v_{\max} = \sqrt{\frac{2 \times 3.125 \times 1.6 \times 10^{-19}}{9.1 \times 10^{-31}}} \approx 10^6 \text{ ms}^{-1}$$

29 **(a)**

$\frac{hc}{\lambda} < W$ (for no emission) $\Rightarrow \lambda > \frac{hc}{W}$

30 **(c)**

$8 \times 10^{14}\, h = \phi_0 + 0.5$

$12 \times 10^{14}\, h = \phi_0 + 2$

Dividing, we get $\frac{12}{8} = \frac{\phi_0 + 2}{\phi_0 + 0.5}$

$$\frac{3}{2} = \frac{\phi_0 + 2}{\phi_0 + 0.5}$$

$3\phi_0 + 1.5 = 2\phi_0 + 4$

or $\phi_0 = 2.5$ eV

31 **(b)**

$$\left(\frac{1}{2}mv^2\right)_{\max} = h\nu - W$$

When ν is doubled (W remians same),

$\left(\frac{1}{2}mv^2\right)_{\max}$

i.e., (KE) is increased. The photoelectric current is directly proportional to the intensity of incident light

32 **(b)**

H discharge tube means max. $h\nu = 13.6$ eV. Work function = 4.2 V. So, $(13.6 - 4.2)$V = 9.4 V. So, required voltage is -9.4 V

33 **(c)**

Effective power $= \frac{25}{100} \times 200$ W

$= 50$ W

Now, $50 = nh\nu = \frac{nhc}{\lambda}$

$$n = \frac{50\lambda}{hc}$$

$$n = \frac{50 \times 0.6 \times 10^{-6}}{6.6 \times 10^{-34} \times 3 \times 10^8} = 1.5 \times 10^{20}$$

34 **(c)**

$V_s = 1.36$ V

$\therefore eV_s = 1.36$ eV

Or $\frac{1}{2}m(v_{\max})^2 = 1.36$ eV

i.e., variation electrons have KE between zero and 1.36 eV

35 **(c)**

According to Einstein's equation,

$E = W_0 + \text{KE}$

$W_{0\max} = 4.2$ eV

KE = 2.6 eV

$\therefore E_{\min} = W_{0\max} + \text{KE} = (4.2 + 2.6)\text{eV} = 6.8$ eV

36 **(c)**

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

$$2E = \frac{hc}{\lambda'} - \phi_0$$

Solving $\lambda' = \frac{hc\lambda}{E\lambda + hc}$

37 **(c)**

Kinetic energy is same, that settles for (c)

Intensity 4-fold, so n 4-fold

38 **(b)**

$$E - W_0 = \frac{1}{2}mv^2 = eV_s$$

Or $\frac{hc}{\lambda} - W_0 = eV_s$

Hence, $\frac{hc}{0.6 \times 10^{-6}} - W_0 = e(0.5)$ (i)

and $\frac{hc}{0.4 \times 10^{-6}} - W_0 = e(1.5)$ (ii)

Solving, we get $W_0 = 1.5$ eV

39 **(a)**

$$\lambda = \frac{0.286}{\sqrt{E}(\text{in eV})} \text{Å}$$

$$\sqrt{E}(\text{in eV}) = \frac{0.286}{0.4} \approx 0.707 \approx \frac{1}{\sqrt{2}}$$

$\therefore E(\text{in eV}) = 0.51$

40 **(c)**

$$n = \frac{\text{power}}{hc/\lambda} = \frac{300 \times 10^{-9}}{6.6 \times 10^{-34} \times 3 \times 10^8}$$

$= 1.5 \times 10^{18}\ \text{m}^{-2}\,\text{s}^{-1} = 1.5 \times 10^{14} \text{cm}^{-2}\text{s}^{-1}$

As only 1 percent of photons cause emission of photoelectrons, number of photo electrons is

$n_e = 1.5 \times 10^{12}\ \text{s}^{-1}$

41 **(c)**

$$K_A = \frac{hc}{\lambda_A} - \phi_0; \quad k_B = \frac{hc}{\lambda_B} - \phi_0$$

But $\lambda_A = 2\lambda_B$, therefore

$$\therefore K_A = \frac{hc}{2\lambda_B} - \phi_0$$

$$K_A = \frac{1}{2}[K_B + \phi_0] - \phi_0$$

or $K_A = \frac{K_B}{2} - \frac{\phi_0}{2}$

$$\therefore K_A < \frac{K_B}{2}$$

42 **(d)**

$K_{\max} = h\nu - \phi$

$= \left(\dfrac{6.63 \times 10^{-34} \times 3 \times 10^8}{0.3 \times 10^{-6} \times 1.6 \times 10^{-19}} - 2.46\right)$ eV

$= 1.68$ eV

Cut-off wavelength, $\lambda_0 = \frac{hc}{\phi} = 505$ nm

The minimum energy required to eject the photo-electrons is equal to work function

43 **(d)**

$\lambda = \dfrac{h}{\sqrt{2meV}}$

$p = \sqrt{2meV}$

$\dfrac{P_e}{P_\alpha} = \sqrt{\dfrac{2m_e eV}{2m_\alpha(2e)V}}$

$\dfrac{p_e}{p_\alpha} = \sqrt{\dfrac{m_e}{2m_\alpha}}$

44 **(a)**

When the positive potential of the ball is enough to hold back the most energetic photoelectron, the ball will not emit photoelectrons

$\dfrac{hc}{\lambda} - \phi = Ve$

$V = \dfrac{\frac{hc}{\lambda} - \phi}{e}$

$= \dfrac{6.63 \times 10^{-34} \times 3 \times 10^8}{200 \times 10^{-9} \times 1.6 \times 10^{-19}} - 3.74$

$= 6.216 - 3.74 = 2.5$ V

45 **(d)**

Order of magnitude calculation is enough

$(2m_e eV)^{1/2} = (2 \times 9 \times 10^{-31} \times 100 \times 1.6 \times 10^{-19})^{1/2}$

$\approx 5 \times 10^{-24}$ Kg ms^{-1}

and $h \approx 6 \times 10^{-34}$ Js

So, $\lambda \approx 10^{-10}$ m

Mid-wavelength in visible region is

$\lambda_0 \approx 5000 \times 10^{-10}$ m

Thus, $\lambda = \lambda_0/5000$

46 **(a)**

$\lambda = \dfrac{h}{\sqrt{2mkT}}$

$= \dfrac{6.62 \times 10^{-34}}{\sqrt{2 \times 1.67 \times 10^{-27} \times 1.38 \times 10^{-23} T}}$ m

$= \dfrac{6.62 \times 10^{-34}}{2.15 \times 10^{-25}\sqrt{T}}$ m $= \dfrac{3.079}{\sqrt{T}} \times 10^{-9}$ m

$\dfrac{30.79}{\sqrt{T}}$ Å $\approx \dfrac{30.8}{\sqrt{T}}$ Å

47 **(a)**

Let m be the mass of particle

$\dfrac{mv^2}{2} = \dfrac{hc}{\lambda_{\text{photon}}}$, where symbols have their usual meanings

$\dfrac{p^2}{2m} = \dfrac{hc}{\lambda_{\text{photon}}}$

and $p = \dfrac{h}{\lambda_{\text{particle}}} \Rightarrow \dfrac{h^2}{2m\lambda^2_{\text{particle}}} = \dfrac{hc}{\lambda_{\text{photon}}}$

$\Rightarrow \dfrac{\lambda_{\text{photon}}}{\lambda_{\text{particle}}} = \dfrac{2mc}{h} \times \lambda_{\text{particle}} = \dfrac{2mc}{h} \times \dfrac{h}{mv}$

$= \dfrac{2c}{0.05c} = 40$

48 **(b)**

$\lambda_{\min} = \frac{hc}{eV}$ where h, c and e are constants. Hence $\lambda_{\min} \propto \frac{1}{V}$

49 **(b)**

We know that mass m in motion and the rest mass m_0 is related through the equation

$m = \dfrac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$

As $v = c, m = \frac{m_0}{\sqrt{1-1}} = \frac{m_0}{0} = \infty$

∴ de Broglie wavelength is

$\lambda = \dfrac{h}{mv} = \dfrac{h}{(\infty)(c)} = 0$

50 **(b)**

Energy corresponding to 2000Å $= 12375/2000$eV $= 6.2$ eV

Maximum kinetic energy is

$(6.2 - 5.01)$eV $= 1.19$ eV

Now, $\frac{1}{2} \times 9.1 \times 10^{-31} \times v^2_{\max}$

$= 1.19 \times 1.6 \times 10^{-19}$

or $v^2_{\max} = \frac{1.19 \times 1.6 \times 10^{-19} \times 2}{9.1 \times 10^{-31}}$

or $v^2_{\max} = 0.418 \times 10^{12} = 41.8 \times 10^{10}$

or $v_{\max} = 6.46 \times 10^5$ ms^{-1}

51 **(d)**

Work function $W_0 = \frac{hc}{\lambda_0}$

$\Rightarrow W_0 = \dfrac{2 \times 10^{-25}}{2 \times 10^{-7}} = 10^{-18}$ J

$= \dfrac{10^{-18}}{1.6 \times 10^{-19}}$ eV $= 6.25$ eV

Energy of incident radiation is $E = \frac{hc}{\lambda} = 31.25$ eV

∴ KE of photoelectrons $= E - W_0 = 25$ eV

52 **(a)**

$E = \dfrac{hc}{\lambda}$

Number of photons emitted is

$$\frac{Pt}{\left(\frac{hc}{\lambda}\right)} = n_0$$

$$n_0 = \frac{P\lambda t}{hc}$$

Since the radiation is spherically symmetric, so total number of photons entering the sensor is n_0 times the ratio of aperture area to the area of a sphere of radius ℓ

$$N = n_0 \frac{\pi(2d)^2}{4\pi\ell^2} = \frac{P\lambda t}{hc}\frac{d^2}{\ell^2}$$

53 **(a)**

Imagine the sphere to be made of thin circular rings of radius r, thickness $ds = R\,dq$ and subtending an angle θ at the center

Momentum per second of incident photons

$$\left(\frac{dP}{dt}\right)_{\text{incident}} = \frac{I}{c} dA \cos^2\theta$$

Since surface of mirror is considered to be ideal i.e., reflection coefficient is unity, photons suffer momentum change in normal direction only

$$\left(\frac{dP}{dt}\right)_{\text{incident}} = \frac{2I}{c} dA \cos^2\theta$$

$$dF_n = \left(\frac{dP}{dt}\right)_{\text{incident}} = +\frac{2I}{c} dA \cos^2\theta$$

This force may be resolved into horizontal and vertical components. The vertical component $dF_n \sin\theta$ is cancelled because every element on the upper half has a symmetrically placed element in the lower half. So, resultant force on the ball,

$$F = \int df_n \cos\theta = \int \frac{2I}{c} dA \cos^3\theta$$

$$dA = (2\pi R \sin\theta) R d\theta$$

$$F = \int_0^{\pi/2} 4\pi \frac{1}{c} R^2 \cos^3\theta \sin\theta\, d\theta$$

$$= \frac{4\pi R^2 I}{c}\int_0^{\pi/2} \cos^3\theta \sin\theta\, d\theta = \frac{\pi R^2 I}{c}$$

On subtracting values, we get $F = 0.8$ μN

54 **(c)**

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

$$= \frac{(6.62\times10^{-34})^2}{2\times4\times1.67\times10^{-27}\times(0.1\times10^{-10})^2} \times \frac{1}{1.6\times10^{-19}} \text{ eV}$$

$$= \frac{43.82\times10^{-68}}{21.376\times10^{-68}} = 2.05 \text{ eV}$$

55 **(b)**

Momentum imparted per unit time $= np$

$$\Rightarrow F = \frac{nh}{\lambda}$$

$$\therefore \text{Acceleration} = \frac{nh}{m\lambda}$$

56 **(b)**

$$h(v_1 - v_2) = e(V_1 - V_2)$$

$$\frac{h}{e} = \frac{1}{c}\frac{(V_1 - V_2)}{\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right)} = \frac{10^{-9}}{3\times10^8}\left(\frac{4.6 - 0.08}{\frac{1}{185} - \frac{1}{546}}\right)$$

$$= \frac{4.42\times185\times546\times10^{-17}}{361\times31}$$

$$= 4.12\times10^{-15} \text{ Js C}^{-1}$$

57 **(a)**

$$\frac{1}{\lambda} \propto (Z-1)^2$$

$$\therefore \quad \frac{\lambda_1}{\lambda_2} = \left(\frac{Z_2 - 1}{Z_1 - 1}\right)^2$$

$$\text{or} \quad \frac{1}{4} = \left(\frac{Z_2 - 1}{11 - 1}\right)^2$$

Solving this we get, $Z_2 = 6$

58 **(c)**

Let us calculate energy corresponding to 0.2×10^{-6} m or $0.2\times10^{-6}\times10^{10}$ Å

or $2000\text{ Å} = \frac{12375}{2000} = 6.1875$ eV

$$\frac{1}{2} m v_{\max}^2 = (6.1875 - 4)\text{eV}$$

or $m v_{\max}^2 = \frac{2\times2.1875\times1.6\times10^{-19}}{9.1\times10^{-31}}$

or $m v_{\max}^2 = 0.769\times10^{12} = 0.876\times10^6$

$= 8.76\times10^5 \text{ ms}^{-1}$

59 **(c)**

$$E_k = \frac{12375}{4000} - \phi = 3.1 - \phi_0$$

$$2E_k = \frac{12375}{3100} - \phi = 3.99 - \phi_0$$

$$6.2 - 2\phi_0 = 3.99 - \phi_0$$

or $\phi_0 = 6.2 - 3.99 = 2.21$ eV

60 **(a)**

$$E = \frac{hc}{\lambda/2} - \phi_0$$

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

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

or $\frac{4hc}{\lambda} - 2\phi_0 = \frac{3hc}{\lambda} - \phi_0$ or $\phi_0 = \frac{hc}{\lambda}$

61 **(d)**

Each photon has associated with it an energy wave given by

$$E = hf = \frac{hc}{\lambda}$$

and graph of E vs, λ is a hyperbola

Thus, $E \propto \frac{1}{\lambda}$

62 **(d)**

$\lambda = \frac{h}{mv}$

Here, $0 \times M = m_1v_1 + m_2v_2$

Clearly, $m_1v_1 = -m_2v_2$

In magnitude,

$mv =$ constant

$\therefore \frac{\lambda_1}{\lambda_2} = \frac{1}{1}$

63 **(b)**

In both the cases, the intensity is same

64 **(b)**

Cut-off wavelength depends on the applied voltage not on the atomic number of the target. Characteristic wavelengths depends on the atomic number of target.

65 **(b)**

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

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

Dividing Eq. (i) and (ii), we get $\lambda_0 = 4\lambda$

66 **(a)**

Energy $= \frac{1}{2}mv^2 = 5000$ eV

$= 5000 \times 1.6 \times 10^{-19}$ J

$mv = \sqrt{2 \times 5000 \times (1.6 \times 10^{-19})m}$

$= 4 \times 10^{-8} \times \sqrt{m}$

Number of electrons striking per second is

$n = \frac{q}{e} = \frac{It}{e} = \frac{50 \times 10^{-6} \times 1}{1.6 \times 10^{-19}} = 31.25 \times 10^{13}$

Force =change of momentum per second

$= n(mv) = 31.25 \times 10^{13} \times 4 \times 10^{-8}\sqrt{m}$

$= 125 \times 10^5\sqrt{9.1 \times 10^{-31}}$

$= 1.1924 \times 10^{-8}$ N

67 **(d)**

$\lambda_P = \lambda_\alpha$

or $\frac{h}{\sqrt{2m_pQ_pV}} = \frac{h}{\sqrt{2m_\alpha Q_\alpha V_\alpha}}$

$\therefore m_pQ_pV_p = m_\alpha Q_\alpha V_\alpha$

$\therefore V_\alpha = \left(\frac{m_p}{m_\alpha}\right)\left(\frac{Q_p}{Q_\alpha}\right)V = \left(\frac{1}{4}\right)\left(\frac{1}{2}\right)V = \frac{V}{8}$

69 **(c)**

Let $h\nu_0 - W_0 = K$ (i)

If frequency is doubled, let kinetic energy of photoelectrons be K_1

$2h\nu_0 - W_0 = K_1$ (ii)

$\Rightarrow 2(h\nu - W_0) + W_0 = K_1$

$\Rightarrow 2K + W_0 = K_1$

i.e., kinetic energy is more than doubled

70 **(c)**

The wavelength of X-ray lines is given by Rydberg Formula $\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

For K_α line, $n_1 = 1$ and $n_2 = 2$

$\therefore \frac{1}{\lambda} = RZ^2\left(\frac{3}{4}\right) \Rightarrow Z = \left(\frac{4}{3R\lambda}\right)^{1/2}$

$= \left[\frac{4}{3(1.097 \times 10^7 m^{-1})(0.76 \times 10^{-10} m)}\right]^{1/2}$

$= 39.99 \approx 40$

71 **(a)**

$\lambda = \frac{hc}{E} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{1 \times 1.6 \times 10^{-19}} \times 10^{10}$Å

$= 12.375 \times 10^3$ Å

72 **(c)**

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

mV =constant

$1837\ V' = 1 \times V$

or $V' = \frac{V}{1837}$ volt

73 **(c)**

$\frac{E_e}{E_{ph}} = \frac{\frac{c}{4}}{2c} = \frac{1}{8}$

74 **(c)**

If E is the energy of incident photon and W the work function, then $E - W_0 =$ available energy

$E - W_0 = \frac{1}{2}mv^2$

or $v = \sqrt{\frac{2(E-W_0)}{m}}$

$\therefore \frac{v_1}{v_2} = \sqrt{\frac{1-0.5}{2.5-0.5}} = \sqrt{\frac{0.5}{2}} = \frac{1}{2}$

75 **(d)**

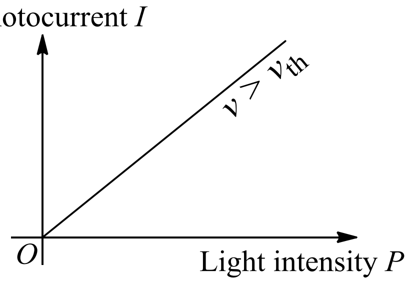
Saturation current is inversely proportional to the square of distance of cathode from point source

76 **(d)**

$\frac{2IA}{c} = F$ and (K_{eq}) parallel $= 3K$

$\Delta X = \frac{2F}{3K} = \frac{4IA}{3Kc}$

77 **(c)**



The rate of emission of photoelectrons (i.e., photocurrent) depends linearly on the rate of incident photons

78 **(a)**

$K_{\max} = hv - W$

ω is the intercept on y-axis and h is the slope

$\therefore h = \frac{2.4 \times 10^{-15}}{4 \times 10^{18}} = 6 \times 10^{-34}$ Js

$W = 2 \times 10^{-15}$J

$\Rightarrow hv_0 = 2 \times 10^{-15}$

Or $v_0 = 3.33 \times 10^{18}$

79 **(d)**

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

So, graph between λ and p is a rectangle hyperbola

80 **(b)**

$W = hv - eV$,

$hv =$ energy of incident photon

Here $hv = \frac{12400}{1240}$ eV $= 10$ eV

$\therefore W = 10 - 8 = 2$ eV

So, $\lambda =$Threshold wavelngth

$= \frac{12400}{2eV}$ Å $= 6200$ Å

81 **(c)**

Using photoelectric equation,

$hv - hv_0 = \frac{1}{2}mv^2 = eV_s$

or $\left(\frac{hc}{\lambda} - \frac{hc}{\lambda_0}\right) = eV_s$

For the first case, $\frac{hc}{\lambda} - \frac{hc}{\lambda_0} = e(3V_0)$ (i)

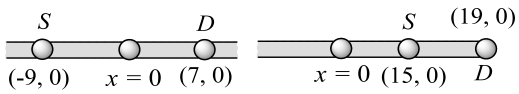
For the second case, $\frac{hc}{2\lambda} - \frac{hc}{\lambda_0} = e(V_0)$ (ii)

Solving $\lambda_0 = 4\lambda$

82 **(b)**

The separation between source and photosensitive material at $t = 0$ is 16 m.

Therefore, intensity received by photosensitive material at $t = 0$ is $I_0 = P/(4\pi \times 16^2)$, where P is the power of source of light



At $t = 3$ s, the source is at (15, 0) and detector is at (19, 0), so the separation between them is 4 m

$I_2 = \frac{P}{4\pi \times 4^2}$

So, $\frac{I_1}{I_2} = \frac{1}{16}$

83 **(b)**

Number of photons falling per second:

$N_p = \frac{10^{-3}}{\frac{6.6\times10^{-34}\times3\times10^8}{5000\times10^{-10}}} = 2.5 \times 10^{15}$

Let N_e is the number of photoelectrons emitted per second

$\therefore I = \frac{q}{t} = \frac{N_e e}{1} \Rightarrow N_e = \frac{I}{e} = \frac{0.16 \times 10^{-6}}{1.6 \times 10^{-19}} = 10^{12}$

Percentage of photons producing photoelectrons

$= \frac{N_e}{N_p} \times 100 = \frac{10^{12}}{2.5 \times 10^{15}} \times 100 = 0.04\%$

84 **(c)**

$E_K - E_L = \frac{hc}{\lambda} = \frac{(6.6 \times 10^{-34})(3 \times 10^8)}{(0.021 \times 10^{-9})(1.6 \times 10^{-19})} eV$

$= 59KeV$

85 **(d)**

$\frac{1}{2}mv^2 = \frac{hc}{\lambda} - W_0$ (i)

Let the speed of the fastest electron be V_1 when excitation wavelength is changed to $3\lambda/4$

$\therefore \frac{1}{2}mv_1^2 = \frac{4hc}{3\lambda} - W_0$

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

$\Rightarrow \frac{1}{2}mv_1^2 = \frac{4}{3}\left(\frac{1}{2}mv^2\right) + \frac{W_0}{3}$ [using Eq. (i)]

$\Rightarrow v_1^2 = \frac{4v^2}{3} + \frac{2W_0}{3m}$

$\therefore v_1 > \sqrt{\frac{4}{3}}\, v$

86 **(c)**

$\lambda_0 = \frac{hc}{W_0} = \frac{12400}{4} = 3100\text{Å} = 310\ nm$

87 **(a)**

$\frac{1}{2}mv^2 = eV$ or $v = \sqrt{\frac{2eV}{m}}$

$= \sqrt{2 \times 1.6 \times 10^{11} \times 200}$ ms^{-1} $= 8 \times 10^6$ ms^{-1}

88 **(a)**

$\lambda_1 = \frac{12375}{E_1(eV)}$ Å $= 1000$ Å

$\therefore E_1 = 12.375$ eV

Similarly, $\frac{12375}{\lambda(\text{Å})}$ eV $= \frac{12375}{2000} = 6.1875$eV

Now, $E_1 - W_0 = eV_s$

and $E_2 - W_0 = eV_S$

Hence, $12.375 - W_0 = 7.7$ eV

and $6.1875 - W_0 = eV_s'$

Solving, we get $V_s' = 1.5$ V

89 **(b)**

Since $E \propto \frac{1}{\lambda}$, so energy corresponding to 5000 Å is

$E = 2.46$ eV

Now, $hv - W = eV_s$

or 2.46 eV $- W = 1.36$ eV

$W = (2.46 - 1.36)$eV $= 1.1$ eV

90 **(a)**

We have KE$= \frac{P^2}{2m_e} = \frac{hc}{\lambda_{\min}}$

$$P=\sqrt{\frac{2hcm_e}{\lambda_{\min}}}$$

Also, $\lambda_{\text{de Broglie}}=\frac{h}{p}=\sqrt{\frac{h\lambda_{\min}}{2m_e c}}$

For $\lambda_{\min}=10$ Å,

$\lambda_{\text{de Broglie}}\cong 0.3$ Å

91 **(c)**

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

or $\lambda=\frac{hc}{ev_s+\phi_0}$

$$\Rightarrow \frac{\lambda_2}{\lambda_1}=\frac{eV_{s_1}+\phi_0}{eV_{S_2}+\phi_0}$$

or $\frac{4500}{4000}=\frac{1.3+\phi_0}{0.9+\phi_0}$

Or $\phi_0=851.3-9\times 0.9$

Solving $\phi_0=(10.4-8.1)=2.3$ eV

92 **(d)**

Let energy corresponding to wavelength of 4000 Å be E

Then,

$$\frac{E}{E'}=\frac{\lambda'}{\lambda} \text{ or } \frac{E}{1.23}=\frac{10.000}{4000}$$

$\therefore E=1.23\times 2.5=3.075$ eV

But $hv-hv_0=\mathrm{eV_s}$

or $3.075\text{ eV}-1.1\text{ eV}=eV_s$

$\therefore V_s=1.975$ V

93 **(a)**

$\lambda=\frac{h}{p}=\frac{h}{\sqrt{2qVm}}$ *or* $\lambda\propto\frac{1}{\sqrt{qm}}$

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

The nearest integer is 3.

94 **(b)**

$\lambda=\frac{h}{\sqrt{2mE_e}}=\frac{hc}{E_{ph}}$ or $2mE_e=\frac{E_{ph}^2}{c^2}$

But $E_e=\frac{1}{2}mv^2$ or $m=\frac{2E_e}{v^2}$

$$\therefore 2\left[\frac{2E_e}{v^2}\right]E_e=\frac{E_{ph}^2}{c^2}$$

or $\frac{4E_e^2}{v^2}=\frac{E_{ph}^2}{c^2}$ or $\frac{E_e^2}{E_{ph}^2}=\frac{v^2}{4c^2}$

or $\frac{E_e}{E_{ph}}=\frac{v}{2c}$

95 **(b)**

Sodium has low work function. So, maximum kinetic energy is more in the case of sodium. Thus, stopping potential is more for sodium

96 **(d)**

$$n=\frac{W}{hc}=\frac{1.7\times 10^{-18}\times 6000\times 10^{-10}}{6.6\times 10^{-34}\times 3\times 10^{8}}$$

$$=\frac{10^{-24}}{2\times 10^{-25}}\approx 5$$

97 **(d)**

Momentum corresponding to incident protons normal to the surface

$$\left(\frac{dP}{dt}\right)_{\text{incident}}=\frac{I}{c}dA\cos^2\theta$$

Since reflection coefficient is ρ, so the momentum of the reflected photons per second normal to surface,

$$\left(\frac{dP}{dt}\right)_{\text{refelcted}}=-\frac{I}{c}dA\rho\cos^2\theta$$

Hence, rate of change of momentum of the photons,

$$\left(\frac{dP}{dt}\right)_{\text{photons}}=-\frac{I}{c}dA(\rho+1)\cos^2\theta$$

From Newton's third law,

$$\left(\frac{dP}{dt}\right)_{\text{surface}}=-\frac{I}{c}dA(\rho+1)\cos^2\theta$$

Hence, pressure exerted on surface,

$$P=\frac{dF}{dA}=\frac{1}{c}dA\,(\rho+1)\cos^2\theta$$

On substituting values, we get $P=0.5\text{ N cm}^{-2}$

98 **(b)**

$$\frac{1}{2}mv^2=hv-\phi_0$$

$$\frac{1}{2}mv'^2=4hv-\phi_0$$

$$\frac{v'^2}{v^2}=\frac{4hv-\phi_0}{hv-\phi_0}$$

Or $\frac{v'^2}{v'}=\frac{4[hv-\phi]+3\phi_0}{hv+\phi_0}$

Clearly, $v'>2v$

99 **(c)**

$$\phi=hv_0=\frac{hc}{\lambda_0}$$

$\phi_0\lambda_0=$ constnat

$4.5\times\lambda=2.3\times 5460$

or $\lambda=\frac{2.3\times 5460}{4.5}$ Å

$=2790.7$ Å ≈ 2791 Å

100 **(b)**

By Einstein's particle (photon) theory, the maximum kinetic energy $E_{\max}$ of the emitted electrons from the cathode is proportional to the frequency f of the light. This is expressed in the Einstein's photoelectric equation below

$E_{\max}=hf-\phi=hf-hf_0$

$=h(f-f_0)$ (i)

Where h is the Planck's constant, ϕ_0 is the work function of the metal and is related to the threshold frequency f_0 by $\phi_0=hf_0$. It is the minimum amount of work or energy necessary to take a free electron out of the metal against the

attractive forces of surrounding positive ions
At a particular negative potential difference V applied to the anode A, the current becomes zero. This is value of the negative potential difference which just stops the electrons with maximum energy from reaching A. V is called the stopping potential. Therefore,

$eV = E_{\max}$ (ii)

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

$eV = E_{\max} = h(f - f_0)$

$V = \frac{h}{e}(f - f_0)$ or $y = \frac{h}{e}(x - x_0)$

The variation of V (or y) is thus a straight line of gradient h/e, when it is plotted against f (or x) at f_0. It is best represented in graph b

101 **(a)**
As work function $W = hv_0$, where v_0 is the threshold frequency
Greater the work function, greater is the threshold frequency. Therefore, the threshold frequency of sodium will be lesser than that for aluminium

102 **(a)**
Option (a) correctly explains the photoelectric effect on the basis of electromagnetic theory. Its correct explanation is given by Quantum theory of light'

103 **(c)**

$\text{KE}_{\max} = hv - \phi$

$\Rightarrow \frac{1}{2}mv_{\max}^2 = hv - \phi$

$\Rightarrow v_{\max} = \sqrt{\frac{2(hv - \phi)}{m}}$

Hence, (a) is incorrect
Since $n = (IA/hv)$, therefore rate of emission of electrons is proportional to the intensity (I)

$\text{KE}_{\max} = hv - \phi$

Hence, (c) is true

104 **(b)**
Maximum KE depends on the frequency of incident radiation, not on intensity

105 **(a)**
Saturation current is proportional to intensity while stopping potential increases with increase in frequency. Hence,

$$v_a = v_b \text{ while } I_a < I_b$$

106 **(a)**

$eV = hv - \phi_0$

$ev = \left(\frac{12375}{2000} - 5.01\right)\text{eV}$

$V = (6.1875 - 5.01)\text{V} = 1.18\text{ V} \approx 1.2\text{ V}$

107 **(c)**
Energy is given by

$E = \frac{m_0c^2}{\sqrt{1 - (v^2/c^2)}}$

or $E^2 = \frac{m^2{}_0c^2}{c^2 - v^2}$

Momentum p is given by

$p = \frac{m_0v}{\sqrt{1(v^2/c^2)}}$

or $p^2c^2 = \frac{m_0^2c^4v^2}{c^2 - v^2}$

$\therefore E^2 - p^2c^2 = m_0^2c^4$ or $E^2 = p^2c^2 + m_0^2c^4$

For photon, rest mass
$m_0 = 0$, so $E = pc$
For electron, $m_0 \neq 0$, so $E \neq pc$

108 **(a)**
V versus f has a constant slope of h/e, so both lines must be parallel
Also, work function is equal to intercept on f-axis

109 **(a)**
Change in intensity from I_0 to $4I_0$ does not affect the stopping potential

110 **(b)**

$\frac{E_e}{E_{ph}} = \frac{\frac{h^2}{2m\lambda^2}}{\frac{hc}{\lambda}} = \frac{h^2}{2m\lambda^2} \times \frac{\lambda}{hc} = \frac{h}{2m\lambda c}$

$= \frac{6.6 \times 10^{-34}}{2 \times 9.1 \times 10^{-31} \times 1.2 \times 10^{-10} \times 3 \times 10^8}$

$= \frac{1}{100}$

111 **(a)**

$E = \frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{632.8 \times 10^{-9}}\text{ J}$

Number of photons per second $n = \frac{P}{E}$

$\Rightarrow n = \frac{5 \times 10^{-3}}{3.14 \times 10^{-19}} = 1.6 \times 10^{16}$

112 **(b)**

$\lambda_1 = \frac{h}{p} = \frac{h}{\sqrt{2mE}}$

$\lambda_2 = \frac{hc}{E}$

So, $\frac{\lambda_1}{\lambda_2} \propto \frac{E}{\sqrt{E}} = E^{1/2}$

113 **(a)**
Kinetic energy gained by a change q after being accelerated through a potential difference V volt

$qV = \frac{1}{2}mv^2$

$v = \sqrt{\frac{2qV}{m}}$

$mv = \sqrt{2mqV}$

De Broglie wavelength $= \lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mqV}}$

$$\frac{\lambda_p}{\lambda_\alpha} = \sqrt{\frac{m_\alpha q_\alpha v_\alpha}{m_p q_p V_p}}$$

Putting $V_\alpha = V_p, \frac{\lambda_p}{\lambda_\alpha} = \sqrt{\frac{4\times 2}{1\times 1}} = 2\sqrt{2}$

114 **(a)**

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

Also, $E = \frac{hc}{\lambda}$

So, if λ is decreased, both p and E increase

115 **(c)**

$eV_s = h\nu - \phi_0$

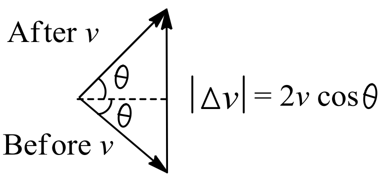
$eV_s' = h\nu' - \phi_0$

$$e(V_s' - V_s) = h\nu' - h\nu = \left(\frac{12375}{3600} - \frac{12375}{4000}\right)$$

$\therefore V_s' - V_s = 3.44 - 3.09 = 0.35$ V

116 **(a)**

Since the molecules rebounded from the wall, the component of velocity perpendicular to the wall is reversed, while its velocity parallel to the wall does not change. The change in velocity of molecules is parallel to normal N. The magnitude of change is



$|\Delta\vec{v}| = 2v\cos\theta$

The change in momentum of a molecule is

$|\Delta\vec{p}| = m|\Delta\vec{v}| = 2mv\cos\theta$

In the direction of normal N. Let n be the number of molecules per unit volume. The number of molecules arriving at an area A of the wall per unit time is the number in a slanted cylinder whose length is equal to the velocity v and whose cross section is $A\cos\theta$

Number of molecules $= n(Av\cos\theta)$

Each molecule suffers a change of momentum $2mv\cos\theta$

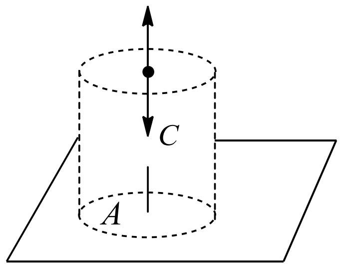
Change of momentum of a stream of gas in a direction perpendicular to the wall is equal to $(nAv\cos\theta) \times (2mv\cos\theta) = 2A\,nmv^2\cos^2\theta$

Hence, force exerted on stream of gas by the wall, $F = 2Anmv^2\cos^2\theta$

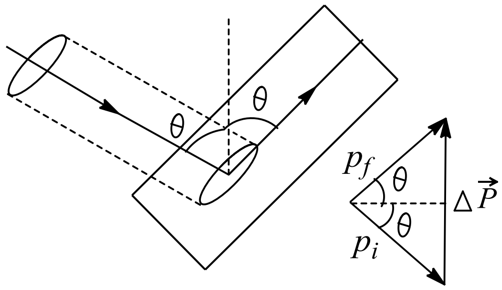
This is also the force exerted by gas molecules on the wall

$$\text{Pressure} = \frac{\text{Normal force}}{\text{Area}} = \frac{F}{A}$$

$= 2nmv^2\cos^2\theta$



(a) Radiation pressure at normal incidence



(b) Radiation pressure at oblique incidence

Remark: For oblique incidence, the change in momentum of the radiation per unit volume at the perfectly reflecting surface is $2p\cos\theta$ and the corresponding radiation pressure is

$P_{\text{rad}} = 2pc\cos^2\theta = 2E\cos^2\theta$

117 **(a)**

Energy radiated as visible light is

$$\frac{5}{100} \times 100 = 5 \text{ J/s}$$

Let n be the number of photons emitted per second. Then,

$$\frac{nh\nu}{\lambda} = 5$$

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

$= 1.4 \times 10^{19}$

118 **(d)**

From conservation of linear momentum, both the particles will have equal and opposite momentum. The de Broglie wavelength is given by

$$\lambda = \frac{h}{p} \Rightarrow \lambda_1/\lambda_2 = 1$$

119 **(b)**

The gain of kinetic energy by an electron is eV

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

$$v = \sqrt{\frac{2eV}{m}} = \sqrt{\frac{2(1.60 \times 10^{-19})(50)}{(9.11 \times 10^{-31})}}$$

$= 4.19 \times 10^6$ ms^{-1}

Thus, the electron's de Broglie wavelength is

$$\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34}}{(9.11 \times 10^{-31})(4.19 \times 19^{6})}$$
$$= 1.74 \times 10^{-10} \text{ m}$$

120 **(a)**

Energy received by the eye,

$$E = \frac{nhc}{\lambda}$$
$$= \frac{5 \times 10^{4} \times 6.6 \times 10^{-34} \times 3 \times 10^{8}}{5000 \times 10^{-10}}$$
$$= 0.2 \times 10^{-13} \text{ Wm}^{-2}$$

So, eye is more sensitive by a factor of $\frac{1}{0.200} = 5.00$

121 **(b)**

The intensity of light at the location of your eye is

$$I = \frac{P}{4\pi r^2} = \frac{60}{4\pi \times 4^2} \text{ Wm}^{-2}$$

The energy entering into your eye per second is

$$P_1 = I \times \frac{\pi d^2}{4}$$

Where d is the diameter of pupil

$$P_1 = \frac{60}{4\pi \times 4^2} \times \frac{\pi \times (2 \times 10^{-3})^2}{4}$$
$$= 9.375 \times 10^{-7} \text{ Js}^{-1}$$

Let n be the number of photons entering into the eye per second, then

$$P_1 = n \times \frac{hc}{\lambda}$$
$$9.375 \times 10^{-7} = n \times \frac{1240 \times 1.6 \times 10^{-19}}{600}$$
$$n = 2.84 \times 10^{12} \text{ photons s}^{-1}$$

So, the number of photons entering the eye in 0.1 s $= 0.1\, n = 2.84 \times 10^{11}$

122 **(b)**

$$\lambda_{\text{ph}} = \lambda_{\text{e}}$$
$$\frac{h}{p_{\text{ph}}} = \frac{h}{p_{\text{e}}}$$
$$\frac{E_{\text{ph}}}{C} = \frac{2E_{\text{e}}}{v}$$
$$\frac{E_{\text{e}}}{E_{\text{ph}}} = \frac{v}{2C}$$

123 **(c)**

$$\phi_0 = h\nu_0$$

or $\phi_0 = e \times 4.14 \times 10^{-15} \times 1 \times 10^{14}$

$= 0.414$ eV

124 **(b)**

$$\lambda = \frac{h}{p} \Rightarrow \lambda = \frac{6.6 \times 10^{-34}}{10^{-31} \times 10^{5}}$$
$$\lambda = 6.6 \times 10^{-8}$$

125 **(d)**

Intensity reduced therefore saturation current reduced. Frequency increased, therefore stopping potential increased

126 **(d)**

Speed of electron which enters into electric filed may increase or decrease while for 2nd electron, it remains constant

So, from $\lambda = \frac{h}{mv'}$

$\lambda_1 > \lambda_2$ or $\lambda_1 < \lambda_2$

127 **(a)**

The photoelectrons will be emitted because wavelength of incident radiation is less than threshold wavelength ($\lambda < \lambda_0$)

128 **(a)**

$$K_p = E_p - \phi_p = \frac{1240}{550} - 2.0 = 0.2545 \text{ eV}$$
$$K_q = E_q - \phi_q = \frac{1240}{450} - 2.5 = 0.255 \text{ eV}$$
$$K_r = E_r - \phi_r = \frac{1240}{350} - 3.0 = 0.543 \text{eV}$$

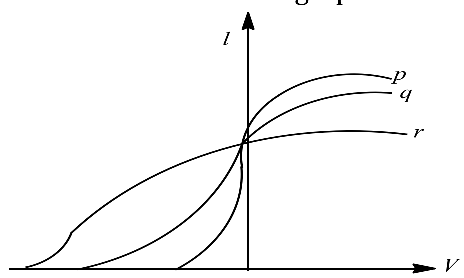
In the above equation K represents maximum kinetic energy of photoelectrons and E, the energy of incident right.

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 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

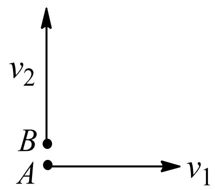


∴ No choice is correct.

129 **(b)**

Let m be the mass of each particle, then

$\lambda_1 = (h/mv_1)$ and $\lambda_2 = (h/mv_2)$, where v_1 and v_2 arte the velocities of two particles as shown in the figure



$$\vec{v}_{CM} = \frac{m\vec{v}_1 + m\vec{v}_2}{2m} = \frac{\vec{v}_1 + \vec{v}_2}{2}$$

Velocity of A w.r.t. C frame is,

$$\vec{v}_{1c} = \vec{v}_1 - \vec{v}_{CM} = \frac{\vec{v}_1 - \vec{v}_2}{2}$$

$$|\vec{v}_{1c}| = \frac{\sqrt{\vec{v}_1 - \vec{v}_2^2}}{2} = |\vec{v}_{2c}|$$

So, required wavelength is

$$\lambda = \frac{h}{m|\vec{v}_{1c}|} = \frac{h}{m} \times \frac{2}{\frac{h}{m}\sqrt{\frac{1}{\lambda_1^2} + \frac{1}{\lambda_2^2}}}$$

$$\lambda = \frac{2\lambda_1\lambda_2}{\sqrt{\lambda_1^2 + \lambda_2^2}}$$

130 **(d)**

Since the number of photoelectrons emitted is directly proportional to the intensity of incident radiation, the number of photoelectrons emitted becomes four times.

The energy of photoelectrons does not change with the intensity light

131 **(c)**

Einstein's equation for photoelectric effect is

$$hv - hv_0 = \frac{1}{2}mv_{\max}^2$$

When $v = 2v_0, v_{\max} = 4 \times 10^8$ cms^{-1}

$2hv_0 - hv_0 = (1/2)m(4 \times 10^8)^2$

$hv_0 = \frac{1}{2}m(4 \times 10^8)^2$ (i)

When $v = 5v_0, v_{\max} = v'$ (ii)

Dividing Eq. (ii) by Eq. (i), we get

$v' = 8 \times 10^8$ cms^{-1}

132 **(a)**

Interatomic spacing in a crystal acts as a diffraction grating

133 **(b)**

Energy of electron in n^{th} orbit, $E_{\text{n}} = -\frac{13.6}{n^2}$eV

For first Bohr orbit, $n = 1$

$E_1 = -13.6$ eV

For second Bohr orbit, $n = 2$

$$E_2 = -\frac{13.6}{4} \text{ eV or } \frac{\lambda_1}{\lambda_2} = \sqrt{\frac{E_2}{E_1}}$$

$$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{1}{4}} \Rightarrow \frac{\lambda_1}{\lambda_2} = \frac{1}{2}$$

134 **(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 $\lambda_0 = \frac{2m\lambda^2 c}{h}$

135 **(d)**

$eV_s = hv - \phi_0$

$$V_s = \frac{h}{e}v - \frac{\phi_0}{e}$$

Now, $\frac{h}{e}$ =slope $= \frac{1.656}{4\times10^{14}} = 0.414 \times 10^{-14}$ Vs

$= 4.14 \times 10^{-15}$ Vs

136 **(d)**

If q is the charge on the particle and V the potential difference through which it is accelerated, then

$$qV = \frac{1}{2}mv^2$$

or $mv = \sqrt{2mqV}$

de Broglie's wavelength,

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

$$\therefore \frac{\lambda_e}{\lambda_p} = \sqrt{\frac{m_p}{m_e}}$$

137 **(b)**

Resolving power is proportional to inverse of wavelength,

i.e., $R \propto \frac{1}{\lambda}$

and $\lambda \propto \frac{1}{P}$

So, $R \propto p = \sqrt{2mE}$

So, $R \propto \sqrt{E}$

$$\frac{R'}{R} = \sqrt{\frac{4kV}{16kV}} = \frac{1}{2}$$

$$R' = \frac{R}{2}$$

138 **(a)**

Energy of dissociation,

$E_s = 10^5$ J mol^{-1}

Photon energy, $E_p = \frac{E_S}{N_a} = \frac{10^5}{6.02\times10^{23}}$

$= 1.66 \times 10^{-19}$ J $= 1.04$ eV

139 **(b)**

On increasing intensity, only saturation current increases, whereas retarding potential remains the same because wavelength of light is unchanged

140 **(c)**

Applying conservation of linear momentum:

Initial momentum = Final momentum

$0 = m_1v_1 - m_2v_2 \Rightarrow m_1v_1 = m_2v_2$

Now $\frac{\lambda_1}{\lambda_2} = \frac{h/m_1v_1}{h/m_2v_2} = 1$

141 **(a,c)**

$$\frac{hc}{\lambda} - \phi = eV$$
$$V = \frac{hc}{e\lambda} - \frac{\phi}{e}$$
For plate 1: Plate 2 Plate 3
$\frac{\phi_1}{hc} = 0.001$ $\frac{\phi_2}{hc} = 0.002$ $\frac{\phi_3}{hc} = 0.004$
$\phi_1 : \phi_2 : \phi_3 = 1 : 2 : 4$
For plate 2, threshold wavelength
$$\lambda = \frac{hc}{\phi_2} = \frac{hc}{0.002hc} = \frac{1000}{2} = 500\ nm$$
For plate 3, threshold wavelength
$$\lambda = \frac{hc}{\phi_3} = \frac{hc}{0.004hc} = \frac{1000}{4} = 250\ nm$$
Since violet colour light λ is 400 $nm, so\ \lambda_{violet} < \lambda_{threshold}$ for plate 2
So, violet colour light will eject photo-electrons from plate 2 and not plate 3

142 **(b,d)**
Since $P = \frac{I}{c} = 10^4\ \text{Nm}^{-2}$
$$P = \frac{E}{A} = \frac{1}{A}\frac{\Delta p}{\Delta t}$$
$\Delta p = P\ A\Delta t = 10^{-5}\ \text{kgms}^{-1}$

143 **(a,b,d)**
The energy of each photon is hc/λ, so that the number of photons released per unit time is $W/(hc/\lambda)$. These photons are spread out in all directions over an area $4\pi a^2$, so that the 'share' of an area S is a fraction $S/4\pi a^2$ of the total number of photons emitted
The maximum energy of emitted photoelectrons is
$$E_{\max} = hc - \phi = \frac{hc}{\lambda} - \phi = \frac{1}{\lambda}(hc - \lambda\phi)$$
The stopping potential is given by
$eV_S = E_{\max}$
Hence, $V_S = \frac{E_{\max}}{e} = \frac{1}{e\lambda}(hc - \lambda\phi)$
Hence, choice (c) is incorrect
For photoemission to be possible, we have $hc \geq \phi$
Hence, $\frac{hc}{\lambda} \geq \phi$ or $\lambda \leq \frac{hc}{\phi}$
Thus, the permitted range of values of λ is
$$0 \leq \lambda \leq \frac{hc}{\phi}$$
Hence, the correct choices are (a), (b), and (d)

144 **(a,b)**
For photoemission, $\lambda < \lambda_0$

145 **(a,b,c)**
For metal A: $4.25 = W_A + T_A$ (i)
Also, $T_A = \frac{1}{2}mv_A^2 = \frac{1}{2}\frac{m^2v_A^2}{m} = \frac{p_A^2}{2m}\ \frac{h^2}{2m\lambda_A^2}$ (ii)
$\left[\because \lambda = \frac{h}{p}\right]$
For metal B: $4.7 = (T_A - 1.5) + W_B$ (iii)
Also, $T_B = \frac{h^2}{2m\lambda_B^2} \times \frac{2m\lambda_A^2}{h^2} = \frac{\lambda_A^2}{\lambda_B^2}$
$$\Rightarrow \frac{T_A - 1.5}{T_A} = \frac{\lambda_A^2}{2\lambda_A^2} = \frac{\lambda_A^2}{4\lambda_A^2} = \frac{1}{4}\ [\because \lambda_B = 2\lambda_A \text{ given}]$$
$\Rightarrow 4T_A - 6 = T_A \Rightarrow T_A = 2\text{eV}$

146 **(a,b,c)**
In a discharge tube electric conduction takes place due to movement of positive ions, negative ions and electrons

147 **(a,c)**
As the source is taken away, the intensity of light reaching the target decreases, and hence the photocurrent decreases
But as motion of the source does not affect frequency of light, the stopping potential given by $V_0 = (hv/e) - (\phi/e)$ remains the same

148 **(b,d)**
$$eV_0 = E_K^{\max} = \frac{hc}{\lambda} - W$$

149 **(b,d)**
As $v > E/B$, so force on electron due to electric field is greater than that due to magnetic field. Due to which the electron will not reach to the undeflected spot on screen but gets deviated in the direction opposite to that of electric field and meets the screen to a spot below the undeflected position

150 **(b,d)**
Since the stopping potential depends on the frequency and not on the intensity and the source is same, the stopping potential remains unaffected. The saturation current depends on the intensity of incident light on the cathode of the photocell which in turn depends on the distance of the source from cathode. The intensity of light is inversely proportional to the square of the distance between the light source and photocell
Intensity $I \propto 1/r^2$ and saturation current $\propto I$ (Intensity)
$$\Rightarrow \text{Saturation current} \propto \frac{1}{r^2}$$
$$\Rightarrow \frac{(\text{Saturation current})_{\text{final}}}{(\text{Saturation current})_{\text{initial}}} = \frac{r_{\text{initial}}^2}{r_{\text{final}}^2}$$
$$\Rightarrow (\text{Saturation current})_{\text{final}} = \frac{0.2 \times 0.2}{0.6 \times 0.6} \times 18$$
$$= 2\ \text{mA}$$

151 **(b,d)**
Electrons are accelerated through a potential

difference.
Hence, depend on voltage applied to tube.
Also, characteristics X-rays depend on target material atomic number

$\sqrt{f}=\sqrt{\frac{c}{\lambda}}=a(Z-b)$

Hence, option (b) and (d) are correct

152 **(a,c,d)**

$P=VI=50\times10^{3}\times20\times10^{-3}=1000\ W$

Power converted into heat $=990\ W$

$ms\Delta T=990\Rightarrow\Delta T=2°\text{C}/sec$

Now $\frac{hc}{\lambda_{\text{min}}}=eV\Rightarrow\lambda_{\text{min}}=\frac{hc}{eV}=0.248\times10^{-10}m$

153 **(a,c)**

Use Einstein's photoelectric equation

154 **(b)**

Stopping potential is the negative potential applied to stop the electrons having maximum kinetic energy. Therefore, stopping potential will be 4 V

155 **(a,b,c)**

Existence of cut-off frequency and photoemission takes place even when intensity is low

156 **(a,b,c)**

Intercept of straight line on negative energy axis given the value of work function of the cathode metal. The point where the straight line cuts the frequency axis gives the value of threshold frequency while the slope of straight line provides the value of Plank's constant

157 **(a,c)**

$$E_{\text{max}}=1\text{eV}=\frac{hv}{\lambda}-\phi_0=\frac{hc}{400\times10^{-9}}-\phi_0$$

As, $\phi_0=1.9$ eV,

Hence, $hc=400\times10^{-9}\times(1+1.9)$

$$\therefore\ E_{\text{max}}=\frac{400\times10^{-9}\times2.9}{500\times10^{-9}}\text{eV}-1.9\text{ eV}$$

$=2.32\text{ eV}=1.9\text{ eV}=0.42\text{ eV}$

$$\lambda_{\text{max}}=\frac{hc}{\phi_0}=\frac{6.6\times10^{-34}\times3\times10^{8}}{1.9\times1.6\times10^{-19}}$$

$=650\times10^{-9}\text{ m}=650\text{nm}$

158 **(c,d)**

If $'V'$ increases then $\lambda_{cut-off}$ will decreases. The no. of electrons striking the target metal, determines the intensity of emitted radiation
Hence, option (c) and (d) are correct

159 **(a,b,c,d)**

$$\frac{1}{2}mv_{\text{max}}^2=v-W$$

Due to magnetic field,

$$\frac{mv_{\text{max}}^2}{r}=Bev_{\text{max}}$$

$$\Rightarrow v_{\text{max}}=\frac{Ber}{m}$$

$$=\frac{5.26\times10^{-6}\times1.6\times10^{-19}\times0.5}{9.1\times10^{-31}}$$

$=0.46\times10^{6}\text{ ms}^{-1}$

$$(\text{KE})_{\text{max}}=\frac{1}{2}mv_{\text{max}}^2=\frac{Bev_{\text{max}}r}{2}$$

$$=\frac{5.26\times10^{-6}\times1.6\times10^{-19}\times0.46\times10^{6}\times0.5}{2}$$

$=0.973\times10^{-19}\text{ J}=0.6\text{ eV}$

Energy of proton,

$$E=\frac{hc}{\lambda}=\frac{1240\text{ eVnm}}{400\text{ nm}}=3.1\text{ eV}$$

Work function, $W=3.1\text{ eV}-0.6\text{ eV}=2.5\text{ eV}$

$(\text{KE})_{\text{max}}=eV_0\ \Rightarrow\ V_0=0.6\text{ V}$

160 **(a,b,c)**

As, $\lambda=\frac{h}{\sqrt{2mE}}$; so $\frac{\lambda_B}{\lambda_A}=\sqrt{\frac{E_A}{E_B}}$

or $2=\sqrt{\frac{E_A}{E_B}}$ or $E_A=4E_B$

or $\frac{E_A}{4}=E_A-1.5$ or $E_A=2.0\text{eV}$

$\phi_A=4.25-2.00=2.25\text{eV};$

$\phi_B=4.70-0.50=4.20\text{eV}.$

161 **(a,b,c)**

Standard result

162 **(c,d)**

The threshold wavelength is 5200 Å. For ejection of electrons, the wavelength of the light should be less than 5200 Å so that frequency increases and hence the energy of incident photon increases. UV light has less wavelength than 5200 Å

163 **(a,b,c,d)**

Energy of photon, $E_0=\frac{hc}{\lambda}$

$$=\frac{6.626\times10^{-34}\times3\times10^{8}}{652\times10^{-9}}$$

$=3.048\times10^{-19}\text{ J}=1.905\text{ eV}$

Energy content in each pulse is

$0.6\text{ W}\times20\times10^{-3}\text{ s}$

$E_p=12\times10^{-3}\text{ J}=12\text{ mJ}$

The number of photons in each pulse is

$$\frac{E_p}{E_o}=\frac{12\times10^{-3}}{3.048\times10^{-19}}$$

$=3.9\times10^{16}\approx4\times10^{16}$

164 **(a,b,c)**

Cut-off wavelength, $\lambda_0=250$ nm

$v_0 = \frac{c}{\lambda_0} = \frac{3 \times 10^8}{250 \times 10^{-9}}$ Hz $= 1.2 \times 10^{15}$ Hz

Work function of the metal,

$W = \frac{hc}{\lambda_0} = \frac{1242 \text{ eV nm}}{250} = 4.968$ eV

$\frac{hc}{\lambda} = \frac{hc}{\lambda_0} + K_{\max}$

$K_{\max} = \frac{1242 \text{ eV nm}}{100 \text{ nm}} - 4.968$ eV

$= 7.432$ eV ≈ 7.4 eV

Photoelectric effect takes place only for light of wavelength less than 250 nm, whereas $\lambda_{\text{red}} \approx 700$ nm

165 **(b,c)**

$E = \phi_0(\text{KE})_{\max}$ $\therefore 4 = \phi_A + T_A$ ...(i)

and $4.5 = \phi_B + (T_A - 1.5)$

or $6 = \phi_B + T_A$ ...(ii)

From Eqs.(i) and (ii), $\phi_B - \phi_A = 2$ ...(iii)

According to de-Broglie hypothesis

$\lambda_A = \frac{h}{mv} = \frac{h}{\sqrt{2mT_A}}$ and $\lambda_B = \frac{h}{\sqrt{2mT_B}}$

$\therefore \frac{\lambda_A}{\lambda_B} = \sqrt{\frac{T_B}{T_A}} = \sqrt{\frac{T_A - 1.5}{T_A}} = \left(1 - \frac{1.5}{T_A}\right)^{1/2}$

$\left(\frac{1}{2}\right)^2 = 1 - \frac{1.5}{T_A}$

On solving, $T_A = 2.0$ eV

$\therefore$ $\phi_A = 4 - T_A = 4 - 2 = 2.0$ eV

$\phi_B = 6 - T_A = 6 - 2 = 4.0$ eV

166 **(a,b,c)**

$K_{max} = E - W_0$

$\therefore T_A = 4.25 - (W_0)_A$ ...(i)

$T_B = (T_A - 1.5) = 4.70 - (W_0)_B$ ...(ii)

Equation (i) and (ii) gives $(W_0)_B - (W_0)_A = 1.95\ eV$

De-Broglie wavelength $\lambda = \frac{h}{\sqrt{2mK}} \Rightarrow \lambda \propto \frac{1}{\sqrt{K}}$

$\Rightarrow \frac{\lambda_B}{\lambda_A} = \sqrt{\frac{K_A}{K_B}} \Rightarrow 2 = \sqrt{\frac{T_A}{T_A - 1.5}} \Rightarrow T_A = 2eV$

From equation (i) and (ii)

$W_A = 2.25\ eV$ and $W_B = 4.20\ eV$

167 **(c)**

$\lambda_{\min} = \frac{hc}{\omega} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{4(1.6 \times 10^{-19})}$

$= 310 \times 10^{-9}$ m

168 **(d)**

On increasing the intensity of incident light, the current in photoelectric cell will increase. The energy of the photons ($h\nu$) will, however not increase with increase in intensity, and hence the kinetic energy of the emitted electrons will not increase

169 **(a)**

The distance between the atoms of crystals is of the order of wavelength of X-rays. When they fall on a crystal, they are diffracted. The diffraction pattern is helpful in the study of crystal structure

170 **(a)**

Energy of photoelectrons emitted is different because after absorbing the photons, electrons within metals collide with other atoms before being ejected out of metal. Hence, Statement II is correct explanation of Statement I

171 **(b)**

Velocity of first photon $= u = c$

Velocity of second photon $= v = -c$

Now, relative velocity of first photon with respect to second photon

$= \frac{u - v}{1 - \frac{uv}{c^2}} = \frac{c - (-c)}{1 - \frac{(c)(-c)}{c^2}}$

$= \frac{2c}{1 + \frac{c^2}{c^2}}$

$= \frac{2c}{1 + 1}$

$= \frac{2c}{2} = c$

Also the rest mass of photon is zero.

172 **(e)**

Soft and hard X-rays differ only in frequency. But both types of X-rays travel with speed of light

173 **(c)**

$KE_{\max} = h\nu = \phi$

$0 \leq KE_{Photoelectrons} \leq KE_{\max}$, Also ϕ of material is constant

174 **(d)**

Einstein's photoelectric equation is given by

$E_k = \frac{1}{2}mv^2 - h\nu - \phi$ .....(i)

(Where v is frequency and ϕ is work function)

When frequency is doubled than Eq. (i) becomes

E'_k=2hv- ϕ

$E'_k = hv$= ,hv- ϕ=(E_k+ ϕ) + E_k

$=2E_k = ϕ$

Therefore, from Eq.(ii)it is quite clear than kinetic energy of emitted photoelectron will be more than two times.

175 **(b)**
Cut-off wavelength depends on the accelerating voltage, not the characteristic X-rays. Further approximately 2% kinetic energy of the electrons is utilised in producing X-rays. Rest 98% is lost in heat.

176 **(c)**
Wavelength of X-ray is very small $(\approx \text{Å})$. Hence they are not diffracted by means of ordinary grating. X-rays follows the Bragg's law

177 **(c)**
A tube light is a gas discharge tube which can emit light of different colours. This colour mainly depends upon the nature of the gas inside the tube and the nature of the glass. The light emitted is due to fluorescence emission of light when argon is filled in tube. It takes place at low pressure but not at high temperature.

178 **(a)**
X-rays lie in electromagnetic spectrum

179 **(a)**
Momentum of a photon is given by $p = \frac{h}{\lambda}$

Also the photon is a form of energy packets behaves as a particle having energy $E = \frac{hc}{\lambda}$.
So $p = \frac{E}{c}$

180 **(b)**
Charge does not change with speed but mass varies with the speed as per relation $m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$.

Hence specific charge e/m decreases with increase in speed

181 **(c)**
Photoelectric effect is based upon quantum theory of light or particle nature of light.

The number of photoelectrons emitted is proportional to intensity of incident light. It does not depend on frequency of light.

182 **(e)**
If electron is moving parallel to the magnetic field, then the electron is not deflected $i.e.$, if electron is not deflected we cannot be sure that there is no magnetic field in that region

183 **(a)**
The photoemissive cell may be evacuated contain an inert gas at low pressure. An inert gas in the cell gives greater current but causes a time lag in the response of the cell to very rapid changes of radiation which may make it unsuitable for some purpose

184 **(c)**
The photoelectric effect is the emission of electrons (called photoelectrons) when light strikes a metal surface. Hence photoelectric effect can take place only with an electron bound in the atom. Electron is a lepton whereas proton is fermion.

185 **(b)**
In photoelectric effect, the photon falling on some matter is absorbed by the matter and its energy is transferred to an electron of the matter. In X-ray production, photons are produced which get energy from energetic electrons ionizing the inner shells of the target which in turn cause a cascade of emission lines

186 **(e)**
Only the photoelectrons emitted from the surface of the metal have maximum kinetic energy. Those emitted from inside the metal loses part of their energy in collision with the other atoms inside the metal

187 **(e)**
Higher the wavelength of X-ray, lesser is the frequency and penetration power

188 **(d)**
At normal pressure positive ions and electrons liberated by ionisation of gas atoms, due to cosmic rays are very small in number and they collide constantly with the gas atoms which are present in large numbers, and hence are unable to move a long distance under the electric field and soon get recombined $i.e.$, flow of ions in the gas does not

take place

189 **(d)**
If electric field is used for detecting the electron beam, then very high voltage will have to be applied or very long tube will have to be taken

191 **(c)**
If V is the accelerating potential and v is the velocity of electron, then

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

$$v \propto \sqrt{V}$$

$$\frac{v_1}{v_2} = \sqrt{\frac{V_1}{V_2}}$$

Here, $V_1 = V, V_2 = 2V, v_1 = v, v_2 = ?$

$$\frac{v_1}{v_2} = \sqrt{\frac{V}{2V}} = \frac{1}{\sqrt{2}}$$

$$v_2 = \sqrt{2}v$$

$$v_2 = 1.4v$$

Reason is false statement, as conditions must be discussed for electron to move on circular path.

192 **(c)**
It is fact that, greater is KE of photoelectron, greater is the potential required to stop it. Hence, stopping potential is a measure of KE of photoelectron. It can be understood from the relation $eV_s = \text{KE}$

or $V_s = \text{KE(in eV)}$

193 **(b)**
de-Broglie wavelength associated with gas molecules varies as

$$\lambda \propto \frac{1}{\sqrt{T}}$$

Also root mean square velocity of gas molecules is

$$v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$$

194 **(a)**
Equivalent mass of photon (m) is given by

$$E = mc^2 = hv \Rightarrow m = \frac{hv}{c^2}$$

Therefore, momentum of photon

$$= mc = \frac{hv}{c^2} \times c = \frac{hv}{c}$$

Thus, photon possessed momentum due to its equivalent mass even its rest mass is zero.

195 **(b)**
de Broglie wavelength associated with a gas molecule varies as, $\lambda \propto 1/\sqrt{T}$

196 **(b)**
The specific charge (e/m) of the positive rays is not universal constant because theses rays may consist of ions of different elements

197 **(d)**
$hv = hv_0 + k_{\text{max}} \Rightarrow k_{\text{max}} = hv - hv_0$

198 **(d)**
When work function of copper is greater than the work function of sodium, then

$\phi_{\text{Cu}} > \phi_{\text{Na}}$

$(hv_0)_{\text{Cu}} > (hv_0)_{\text{Na}}$ ...(i)

But we know that $v_0 = \frac{c}{\lambda_0}$

Hence Eq.(i) becomes

$$\left(\frac{hc}{\lambda_0}\right)_{\text{cu}} > \left(\frac{hc}{\lambda_0}\right)_{\text{Na}}$$

$(\lambda_0)_{\text{Na}} > (\lambda_0)_{\text{Cu}}$

199 **(e)**
In Milkan's experiment oil drops should be of microscope sizes. If much bigger oil drops are used, then a very high electric field will be required to balance it which is not possible to achieve practically

Further, the apparent weight of the liquid
$\frac{4}{3}\pi a^3 g\left(\rho_{\text{liquid}} - \sigma_{\text{air}}\right) = 6\pi a\, \eta v$

If a is large, v will be large and the experimental errors will be high

200 **(b)**
It is true that photocells are utilised to reproduce

sound in cinematography and also in camera and television for scanning ad telecasting the scene. Now, the photocell is such a device in which light energy is converted into electrical energy.

201 **(d)**

Light is produced in gases in the process of electric discharge at low pressure. When accelerated electrons collide with atoms of the gas, atoms get excited. The excited atoms return to their normal state and in this process light radiations are emitted

202 **(c)**

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

203 **(b)**

Specific charge of a positive ion corresponding to one gas is fixed but it is different for different gases

204 **(e)**

The atomic number (number of electrons or protons) remains same in isotope. Isotope of an element can be separated on account of their different atomic weight by using mass spectrograph

205 **(b)**

There is no emission of photoelectrons till the frequency of incident light is less than a minimum frequency, however intense light it may be. In photoelectric effect, it is a single particle collision. Intensity is $hv \times N$, where hv is the individual energy of the photon and N is the total number of photons. In the wave theory, the intensity is proportional, not only to v^2 but also to the amplitude squared. For the same frequency, increase in intensity only increase the number of photons (in the quantum theory of Einstein)

206 **(b)**

Work function is the minium energy required to eject the photoelectron from photosensitive metal. Hence, for metal to be photosensitive, the work function should be small work function$=hf_{0'}$ where fo is threshold frequency.

208 **(b)**

The penetrating power of X-rays depends upon the voltage applied across the tube producing X-rays. X-rays can pass through matter of lighter elecments such as flesh (which is composed of oxygen, hydrogen and carbon) but cannot pass through substances made of heavier elements like bones (which are made of phosphorus and calcium)

209 **(d)**

According to Einstein's equation $KE = hv - hv_0$; $i.e.$, KE depends upon the frequency. Photoelectrons are emitted only if incident frequency is more than threshold frequency

210 **(a)**

Einstein's photoelectric equation is

$$\frac{1}{2}\mathrm{m}v^2 = eV_s = hv - \phi_0$$

or $V_s = \frac{hv}{e} - \frac{\phi_0}{e}$

This is the equation of a straight line, hence the graph between v and V_s is a straight line which is not passing through origin. Also, from the resulting equation. Slope of the graph is h/e, where h is Planck's constant.

211 **(c)**

Since the frequency of ultraviolet light is less than the frequency of X-rays, the energy of each incident photon will be more for X-rays

$$KE_{photoelectron} = hv - \phi$$

Stopping potential is to stop the fastest photoelectron

$$V_0 = \frac{hv}{e} - \frac{\phi}{\mathrm{e}}$$

So, KE_{max} and V_0 both increases.

But KE ranges from zero to KE_{max} because of loss of energy due to subsequent collisions before getting ejected and not due to range of frequencies in the incident light.

212 **(c)**

Intensity of X-rays (I) is proportional to the filament current and also to the square of the voltage. It is well known that intensity of X-rays depends on the number of photons emitted per second from target

213 **(b)**

Mass of moving photon $m = \frac{hv}{c^2} = \frac{h}{c\lambda}$ and $E = mc^2$

214 **(d)**
The work function has no effect on photoelectric current so long as $hv > W_2$. The photoelectric current is proportional to the intensity of incident light. Since, there is no change in intensity of light. Hence, $I_1 = I_2$

Therefore, reason is true but assertion is false

216 **(c)**
1. If intensity changes, then number of photons/time incident on the metal surface change and hence number of photoelectrons liberated change, so saturation photocurrent changes. Stopping potential and KE_{max} will remain the same
2. From $eV_0 = hf - \phi$ and $K_{max} = hf - \phi$

   If f changes, then V_0 and K_{max} change
3. From $eV_0 = hf - \phi$ and $K_{max} = hf - \phi$

   If target material changes, then ϕ changes, then V_0 and K_{max} change
4. If we change the potential difference between emitter and collector, then time taken for electrons to eject changes

217 **(a)**
1. Bichromatic light source is having two wavelengths and hence from energy point of view, two types of photons are possible. As light propagates in different directions, the photon can have different or same momenta depending upon the magnitude and direction of photon motion
2. Same reasoning as for (a)
3. For a monochromatic light source, all photons have same energy but momenta can be different due to different directions
4. Laser is a very narrow beam of monochromatic light, so all photons have nearly same energy and momenta

218 **(a)**
1. From $eV_0 = hf - \phi$ and $K_{max} = hf - \phi$

   If f incraeses keeping ϕ constnat, then V_0 and K_{max} increase
2. If I increases, more photons/time are incident on the metal surface and more photoelectrons would be liberated. Hence, saturation photocurrent increases. Stopping potential and KE_{max} will remain the same
3. If separation between cathode and anode is increased, then there is no effect on V_0, K_{max} or current
4. If ϕ decraeses keeping f and I constant, then V_0 and K_{max} increase

219 **(d)**
Consider two equations
$eV_s = \frac{1}{2}mv_{max}^2 - hf - \phi_0$ (i)
No. of photoelectrons ejected per second ∝ intensity (ii)
1. As frequency is increased keeping intensity constant, V_S will increase and hence, $1/2m(v_{max}^2)$ will increase
2. As frequency is increased and intensity is decreased, V_S will increase and hence $1/2m(v_{max}^2)$ will increase and saturation current will decrease
3. It work function is increased, photoemission may stop
4. If intensity is increased, then saturation current will increase

220 **(b)**
a. Maximum kinetic energy of ejected electron is given by Einstein's photoelectric equation $K_{max} = hf - (hf/3) = 2hf/3$. As no potential difference is applied across target and collector and vacuum is there in the tube, so this maximum KE remains same at all locations

b, c and **d**. Kinetic energy of ejected photoelectrons can be anything from 0 to K_{max} (as found for a). It remains the same at all locations (reasoning is same as for above)

221 **(a)**
Maximum kinetic energy
$K_{max} = hv - \phi_0 = eV$

$\therefore V = \dfrac{hv - \phi_0}{e}$

222 **(a)**

$\lambda = \dfrac{12.27\text{Å}}{\sqrt{V}} = \dfrac{12.27}{\sqrt{64}} = 1.534$ Å

223 **(b)**

$\lambda_0 = 3800$ Å

$W = hf_0 = h\dfrac{c}{\lambda_0} = \dfrac{6.633 \times 10^{-34} \times 3 \times 10^8}{3800 \times 10^{-10}}$

$= 5.23 \times 10^{-19}\text{J} = 3.27$ eV

Incident wavelength $\lambda = 2600$ Å

$f =$ Incident frequency $= \frac{3\times10^8}{2600\times10^{-10}}$ Hz

Then,

$\text{KE}_{\text{max}} = hf - W_0$

$hf = \dfrac{6.63 \times 10^{-34} \times 3 \times 10^8}{2600 \times 10^{-10}}$

$= 7.65 \times 10^{-19}$ J $= 4.78$ eV

$\text{KE}_{\text{max}} = hf - W_0 = 4.78\text{ eV} - 3.27\text{ eV} = 1.51$ eV

$\text{KE}_{\text{max}} = \dfrac{1}{2}mv_{\text{max}}^2$

$v_{\text{max}} = \sqrt{\dfrac{2\text{KE}_{\text{max}}}{m}}$

224 **(d)**

Energy of a photon of wavelength λ,

$E = hv = (hc/\lambda)$

$E = \dfrac{(6.6 \times 10^{-34}) \times (3 \times 10^8)}{6000 \times 10^{-10}}$

$= 3.3 \times 10^{-19}$ J

So, if n is the number of photons emitted per second,

$nE = \dfrac{\text{energy}}{\text{second}} = \text{power}(P)$

Hence, $n = \frac{P}{E} = \frac{100}{3.3\times10^{-19}}$

$\approx 3 \times 10^{20}$, photons s^{-1}

225 **(c)**

From Einstein's photoelectric effect equation,

$\dfrac{hc}{\lambda} = \phi_0 + \dfrac{1}{2}mv^2$

For $\lambda_1 = 3000$ Å,

$\frac{hc}{3000\times10^{-10}} = \phi_0 + \frac{1}{2}m(3v)^2$ (i)

For $\lambda_1 = 6000$ Å,

$\frac{hc}{6000\times10^{-10}} = \phi_0 + \frac{1}{2}mv^2$ (ii)

Now, on multiplying Eq. (ii) by 9 and subtracting Eq. (i). from it, we get

$8\phi_0 = 9\ \dfrac{hc}{6000 \times 10^{-10}} - \dfrac{hx}{3000 \times 10^{-10}}$

Subtracting the values, we get

$\phi_0 = 1.23$ eV

Maximum speed of the photoelectrons will be for the incident light of wavelength $\lambda = 3000$ Å. From Eq. (i)

$\dfrac{1}{2}m(3v)^2 = \dfrac{6.62 \times 10^{-34} \times 3 \times 10^8}{3000 \times 10^{-10}} - 2.896 \times 10^{-19}$

$= 3.724 \times 10^{-19}$

$\therefore 3v = v_{\text{max}}\left(\dfrac{2 \times 3.724 \times 10^{-19}}{9.1 \times 10^{-31}}\right)^{1/2}$

$= 9 \times 10^5$ ms^{-1}

226 **(b)**

The energy of each photon is

$E = hv$

Since the wavelength and frequency are related to the speed of light by

$c = v\lambda$

$E = \dfrac{hc}{\lambda} = \dfrac{(6.626 \times 10^{-34})(3.00 \times 10^8)}{632.8 \times 10^{-9}}$

$= 3.14 \times 10^{-19}$J

1 eV $= 1.602 \times 10^{-19}$ J

$E = \dfrac{3.14 \times 10^{-19}}{1.602 \times 10^{-19}} = 1.96$ eV

The number of photons emitted per second is equal to the energy emitted by the laser each second divided by the energy of one photon

$N = \dfrac{1.00 \times 10^{-3}}{3.14 \times 10^{-19}} = 3.18 \times 10^{15}$ photons s^{-1}

$hc = (6.626 \times 10^{-34})(3 \times 10^8)$

$= 1.99 \times 10^{-25}$ Jm $= 1.24 \times 10^3$ eV nm

If a light of wavelength λ nm is incident, energy of photon, in eV, is

$E = \dfrac{1.24 \times 10^3}{\lambda}$

227 **(a)**

From Einstein's relation,

$eV_s = hv - W$

As work function is a constant for a surface,

$e(V_{s_2} - V_{s_1}) = h(v_2 - v_1)$

$V_{s_2} = V_{s_1} + \dfrac{h}{e}(v_2 - v_1)$

$= V_{s_1} + \dfrac{hc}{e}\left(\dfrac{1}{\lambda_2} - \dfrac{1}{\lambda_1}\right)$

$= 0.19 + 1240\left(\dfrac{1}{190} - \dfrac{1}{550}\right) = 4.47$ V

$W = \dfrac{hc}{\lambda_1} - eV_{s_1} = \dfrac{1240}{550} - 0.19 = 2.07$ eV

$hv_c = W$

$v_e = \dfrac{W}{h} = \dfrac{(2.07)(1.602 \times 10^{-19})}{6.626 \times 10^{-34}}$

$\approx 500 \times 10^{12}$ Hz

228 **(d)**

Energy of photon, $E = \frac{hc}{\lambda}$

$= \dfrac{1.24 \times 10^3}{400} = 3.1 \text{ eV}$

Remaining energy $= 3.1 - 0.31 = 2.79$ eV

Energy lost in first collision is

$(3.1) \times \left(\dfrac{10}{100}\right) = 0.31 \text{ eV}$

Remaining energy is

$3.1 - 0.31 = 2.79$ eV

Energy lost in second collision is

$(2.79) \times \left(\dfrac{10}{100}\right) = 0.279 \text{ eV}$

Total energy lost in two collisions is

$(0.31) + (0.279)\text{eV} = 0.589 \text{ eV}$

So, from conservation of energy, we have

$\frac{hc}{\lambda} = \phi + \text{KE}_{\text{max}}$ +energy lost in two collision

$3.1 = 2.2 + \text{KE}_{\text{max}} + 0.589$

$\text{KE}_{\text{max}} = 0.31 \text{ eV}$

Total energy after second collision is

$(2.79 - 0.279) = 2.511 \text{ eV}$

Energy lost in third collision is

$2.511 \times \dfrac{10}{100} = 0.2511 \text{ eV}$

Reaming energy $= (2.511 - 0.2155)$

$= 2.2599$ eV

Energy lost in fourth collision

$= \left(2.2599 \times \dfrac{10}{100}\right) = 0.2259 \text{ eV}$

Remaining energy $= (2.2599 - 0.2259) = 2.034$ eV

After the fourth collision, the electron does not have enough energy to overcome the work function, so it cannot come out

229 **(d)**

If P is the power of point source of light, the intensity at a distance r is

$I = \dfrac{P}{4\pi r^2}$

The energy intercepted by the metallic sphere is

E =intensity × projected area of sphere= $\frac{\text{P}}{4\pi r^2} \times \pi R^2$

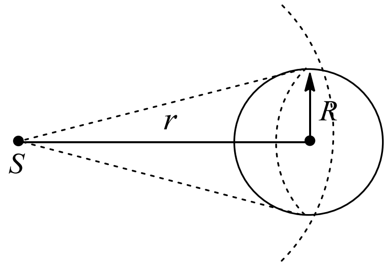
If e is the energy of the single photon and η the efficiency of the photon to liberate an electron, the number of ejected electrons is

$\eta \dfrac{PR^2}{4r^2 e}$

$= \dfrac{(10^{-6})(3.2 \times 10^{-3})(8 \times 10^{-3})^2}{4 \times (0.8)^2 \times (5 \times 1.6 \times 10^{-19})}$

$= 10^5$ electron/s^{-1}

The emission of electrons from a metallic sphere leaves it positively charged. As the potential of the charged sphere begins to rise, it attracts emitted electrons. The emission of electrons will stop when the kinetic energy of the electrons is neutralised by the retarding potential of the sphere. So, we have



$eV = \text{KE}_{\text{max}}$

$V = \left(\dfrac{\text{KE}_{\text{max}}}{e}\right)$

From Einstein's photoelectric equation,

$\text{KE}_{\text{max}} = hv - \phi = (5 - 3) = 2 \text{ eV}$

The potential of a charged sphere is

$V = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q}{R} = \dfrac{1}{4\pi\varepsilon_0}\left(\dfrac{ne}{R}\right)$

$\dfrac{1}{4\pi\varepsilon_0}\left(\dfrac{ne}{R}\right) = 2$

$n = \dfrac{4\pi\varepsilon_0 2R}{e}$

$= \dfrac{2 \times 8 \times 10^{-3}}{9 \times 10^9 \times 1.6 \times 10^{-19}} = 1.11 \times 10^7$

The photoelectric effect will stop when 1.11×10^7 electrons have been emitted

The time taken by it to emit 1.11×10^7 electrons,

$t = \dfrac{1.11 \times 10^7}{10^5} = 111\text{s} = 1.85 \text{ min}$

230 **(b)**

Pressure exerted by absorbed light $= \frac{1}{2}\left(\frac{S}{c}\right)$

Pressure exerted by reflected light $= \frac{1}{2}\left(\frac{2S}{c}\right)$

Total radiation pressure on the surface is

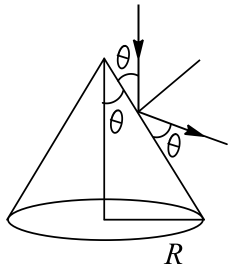
$P_{\text{rad}} = \dfrac{\frac{3}{2}S}{c} = \dfrac{1.5 \times 10^3}{3 \times 10^8} = 5 \times 10^{-6} \text{ Pa}$

$\dfrac{P_{\text{rad}}}{P_0} = \dfrac{5 \times 10^{-6}}{1 \times 10^5} = 5 \times 10^{-11}$

231 **(d)**

Power of light received by the cone $= I(\pi R^2)$

Let number of photons hitting the cone per second is n



Then, $nE = I\pi R^2 \Rightarrow n = \pi R^2 I/E$

By symmetry, the net force on the cone will be vertically downward

Force due to one photon:

$$f = 2\frac{h}{\lambda}\sin\theta$$

This force is perpendicular to the surface of cone. Hence, net force on the cone will be

$$F = nf\sin\theta = n\left(2\frac{h}{\lambda}\sin\theta\right)\sin\theta$$

$$= \frac{\pi R^2 I}{c}(1-\cos 2\theta)$$

232 **(c)**

$$Q = CV \Rightarrow ne = \frac{\varepsilon_0 A}{d}V$$

$$n = \frac{2.85\times10^{-12}\times10}{0.5\times10^{-3}\times1.6\times10^{-19}}\times16$$

$$n = 8.85\times10^9$$

233 **(a)**

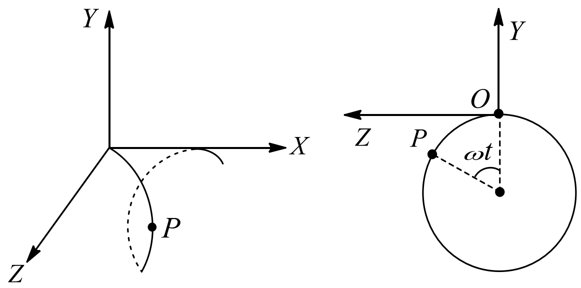
At any time t the location of electrons is shown as P. In two dimensional view of electron in YZ-plane, the situation is more clear

$$v = \sqrt{\frac{2\text{KE}}{m}} = \sqrt{\frac{2(hv-\phi)}{m}}$$

$$p = v\cos\theta\frac{2\pi m}{qB_0}$$

$$pqB_0 = 2\pi\cos\theta\, m\sqrt{\frac{2(hv-\phi)}{m}}$$

$$= 2\pi\cos\theta = \sqrt{2m(hv-\phi)}$$



X-coordinte, $x = v\cos\theta\times t$

Y-coordinte, $y = -[R - R\cos\omega t]$

Z-coordinte, $z = R\sin\omega t$

So, $z = \frac{mv\sin\theta}{qB_0}\times\sin\left[\frac{qB_0}{m}t\right]$

$$= \frac{\sqrt{2m(hv-\phi)}\times\sin\theta}{qB_0}\times\sin\left[\frac{qB_0 t}{m}\right]$$

From $x = v\cos\theta\times t = \frac{\sqrt{2(hv-\phi)}}{m}\times\cos\theta\times t$

As v increase, slope of x versus t graph (a straight line) increases

234 **(b)**

$\text{KE}_1 = hv - \phi$

$\text{KE}_2 = nhv - \phi$

$= n(hv-\phi) + (n-1)\phi$

$\text{KE}_2 = n\text{KE}_1 + (n-1)\phi$

$\text{KE}_2 < n\text{KE}_1$

235 **(a)**

The effective area of Earth receiving radiation normally

$$= \pi\left(\frac{D}{2}\right)^2$$

$$= \pi\left(\frac{1.27\times10^4}{4}\right)\text{ sq km}$$

Energy received by Earth per minute is

$$\frac{\pi}{4}(1.27)^2\times10^{18}\times2\times4.2$$

$$= 10.645\times10^{18}\text{ J min}^{-1}$$

236 **(b)**

The energy of the incident photon is

$$E = \frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{3300 \times 10^{-10}}$$
$= 3.75$ eV

A will not emit photoelectrons because energy of incident photon is less than work function of A

237 **(c)**

$$\frac{1}{2}mv^2 = ev$$
$$v = \sqrt{\frac{2ev}{n}}$$
$$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mev}}$$
Fringe width $B = \frac{\lambda D}{d}$
$$= \frac{hD}{d\sqrt{2mev}}$$

238 **(b)**

Energy required,
$$E = ms\Delta\theta + mL$$
$$= 2 \times 10^{-9} \times 4.2 \times 10^3 \times 70 + 2 \times 10^{-9} \times 2.25 \times 10^6$$
$$= 5.088 \times 10^{-3}\ \text{J} = 3.18 \times 10^{16}\ \text{eV}$$

239 **(a)**

Using $2d \sin\theta = n\lambda$; where $\theta = (90 - i)$
$\Rightarrow 2d\sin(90 - i) = n\lambda \Rightarrow 2d\cos i = n\lambda$

240 **(c)**

$$\left[\sqrt{\frac{Ne^2}{m\epsilon_0}}\right] = \sqrt{\frac{\frac{1}{L^3} \times Q^2}{M \times \frac{Q^2}{L^2 \times F}}} = \frac{1}{T}$$
So, only (c) is dimensionally correct

241 **(1)**

Let n photons (each of frequency f) per second are emitted from source. Then power of source is $P = nhf$

But only 30% of the photons go towards mirrors

Then force exerted on mirror is
$$F = 2\left[\frac{30}{100}n\right]\frac{h}{\lambda} = \frac{3}{5}\frac{nhf}{c} = \frac{3}{5}\frac{P}{c}$$
and this force should be equal to weight of mirror, so
$$\frac{3}{5}\frac{P}{c} = 20 \times 10^{-3}\ \text{g}$$
$$\Rightarrow P = \frac{5 \times 3 \times 10^8 \times 20 \times 10^{-3} \times 10}{3} = 10^8\ \text{W}$$

242 **(4)**

The energy of each photon $= \frac{200\ \text{J/s}}{4 \times 10^{20}/\text{s}} = 5 \times 10^{-19}$ J

Wavelength $= \lambda = \frac{hc}{E}$
$$= \frac{(6.63 \times 10^{-34}\text{J} - \text{s}) \times (3 \times 10^8\ \text{m/s})}{(5 \times 10^{-19}\ \text{J})}$$
$= 4.0 \times 10^{-7}$ m

243 **(7)**

$$\frac{hc}{\lambda} = \phi + eV$$
$$\frac{1240(eV)(nm)}{200(nm)} = 4.7(eV) + eV$$
$$\frac{1240}{200}e = 4.7e + eV$$
$6.2 - 4.7 = V \quad \therefore V = 1.5\ volt$
$$\frac{1}{4\pi\varepsilon_0}\frac{Q}{R} = 1.5$$
$$(9 \times 10^9)\frac{Ne}{\frac{1}{100}} = 1.5$$
$$9 \times 10^{11}\ Ne = 1.5$$
$$N = \frac{1.5}{9 \times 10^{11} \times 1.6 \times 10^{-19}} = \frac{15}{16} \times \frac{1}{9} \times 10^8$$
$$= \frac{5}{3 \times 16} \times 10^8 = \frac{50}{48} \times 10^7$$
$\therefore Z = 7$

244 **(3)**

Given $\lambda \times 200$ nm $= 2 \times 10^{-7}$ m

Energy of one photon is
$$\frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{2 \times 10^{-7}} = 9.945 \times 10^{-19}$$
Number of photons is
$$\frac{1 \times 10^{-7}}{9.945 \times 10^{-19}} = 1 \times 10^{11}$$
Hence, number of photoelectrons emitted is
$$\frac{1 \times 10^{11}}{10^4} = 1 \times 10^7$$
Net amount of +ve change 'q' developed due to the outgoing electrons$= 1 \times 10^7 \times 1.6 \times 10^{-19} = 1.6 \times 10^{-12}$ C

Now potential developed at the centre as well as at the surface due to these charges is
$$\frac{Kq}{r} = \frac{9 \times 10^9 \times 1.6 \times 10^{-12}}{4.8 \times 10^{-2}} = 3 \times 10^{-1}\ \text{V}$$
$= 0.3$ V

245 **(4)**

Speed of photon $(c) = 3 \times 10^8\ \text{ms}^{-1}$. Let λ be the wavelength of the photon. The de Broglie wavelength of the electron is h/mv

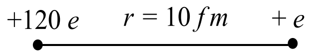
Given $\lambda = \frac{h}{mv}$. Now

$$\frac{\text{K.E. of photon}}{\text{K.E. of electron}} = \frac{hf}{(1/2)mv^2} = \frac{2hc}{mv^2\lambda} = \frac{2c}{v}$$

$$\left(\because \lambda = \frac{h}{mv}\right)$$

$$= \frac{2 \times 3 \times 10^8}{1.5 \times 10^8} = 4$$

246 **(7)**



$$\frac{(9 \times 10^9)(120e)(e)}{10 \times 10^{-15}} = \frac{p^2}{2m}$$

$$\lambda = \frac{h}{p} \therefore p^2 = \frac{h^2}{\lambda^2}$$

$$2\left(\frac{5}{3} \times 10^{-27}\right) 10^{15}(9 \times 10^9)(12)e^2 = \frac{h^2}{\lambda^2}$$

$$(120)(3)10^{-27+15+9}\,\lambda^2 = (4.2)^2 \times 10^{-30}$$

$$\lambda^2 = \frac{4.2 \times 4.2 \times 10^{-30}}{360 \times 10^{-3}} = \frac{42 \times 42}{360} \times 10^{-29}$$

$$= 7^2 \times 10^{-30} \Rightarrow \lambda = 7 \times 10^{-15} m = 7\ fm$$

247 **(1)**

$\lambda = 663 \times 10^{-9}$m, $\theta = 60°$, $n = 1.0 \times 10^{19}$

$$P = \frac{h}{\lambda} = \frac{6.63 \times 10^{-34}}{6.63 \times 10^{-9}} = 10^{-27}$$

Force exerted on the wall is

$$n \times 2 \times P\cos\theta = 2 \times 1 \times 10^{19} \times 10^{-27} \times \frac{1}{2}$$

$$= 1 \times 10^{-8}\ \text{N}$$

248 **(1)**

$$r \propto \frac{P}{q} \left(\text{since}, r = \frac{P}{Bq}\right)$$

Where P =momentum, Given $r_\alpha = \frac{1}{2} r_e$

$$\frac{P_\alpha}{B2e} = \frac{1}{2}\left(\frac{P_e}{Be}\right) \text{ or } P_\alpha = P_e$$

$$\lambda \propto \frac{1}{P} \quad \left(\text{since}, \lambda = \frac{h}{p}\right)$$

So, $\lambda\alpha = \lambda_e$ or $n = 1$

249 **(9)**

Given: Fringe width,

$y = 1.0 \text{ mm} \times 2 = 2.0 \text{ mm}$

$d = 0.24$ mm, $W_0 = 2.2$ eV, $D = 1.2$ m

$$y = \frac{\lambda D}{d} \text{ or } \lambda = \frac{yd}{D}$$

$$= \frac{2 \times 10^{-3} \times 0.24 \times 10^{-3}}{1.2} = 4 \times 10^{-7}\ \text{m}$$

$$E = \frac{hc}{\lambda} = \frac{4.14 \times 10^{-15} \times 3 \times 10^8}{4 \times 10^{-7}} = 3.105\ \text{eV}$$

Stopping potential

$eV_0 = 3.105 - 2.2 = 0.905$ eV

$$V_0 = \frac{0.905}{1.6 \times 10^{-19}} \times 1.6 \times 10^{-19}\ \text{V} = 0.905\ \text{V}$$

250 **(5)**

For K_α X-ray, $(Z-1)^2\lambda$ = constant. Hence,

$(9-1)^2\lambda = (Z-1)^2(4\lambda)$

$$(Z-1)^2 = \frac{64}{4} = 16$$

$Z - 1 = 4$ or $Z = 5$