PRACTICE EXERCISES

SINGLE CORRECT CHOICE TYPE QUESTIONS

This section contains Single Correct Choice Type Questions. Each question has four choices (A), (B), (C) and (D), out of which ONLY ONE is correct.

1. Consider a source emitting 100 W of green light at a wavelength of 500 nm. The number of photons emerging from source per second is

(A) 2.5×10^{19} photon per second

(B) 25×10^{20} photon per second

(C) 25×10^{19} photon per second

(D) 25×10^{17} photon per second

2. The distance d of a 100 W lamp is continuously increased from a photocell. The photoelectric current I varies with distance d as

(A) $I\propto d^2$ (B) $I\propto d$

(C) $I\propto\dfrac{1}{d^2}$ (D) $I\propto\dfrac{1}{d}$

3. When a metallic surface is illuminated with monochromatic light of wavelength λ, the stopping potential is $5V_0$. When the same surface is illuminated with light of wavelength 3λ, the stopping potential is V_0. Then the work function of the metallic surface is

(A) $\dfrac{hc}{6\lambda}$ (B) $\dfrac{hc}{5\lambda}$

(C) $\dfrac{hc}{4\lambda}$ (D) $\dfrac{2hc}{4\lambda}$

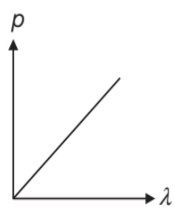
4. An electron of mass m, when accelerated through a potential difference V has de-Broglie wavelength λ. The de-Broglie wavelength associated with a proton of mass M accelerated through the same potential difference will be

(A) $\lambda\left(\dfrac{m}{M}\right)$ (B) $\lambda\sqrt{\dfrac{m}{M}}$

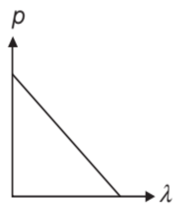
(C) $\lambda\left(\dfrac{M}{m}\right)$ (D) $\lambda\sqrt{\dfrac{M}{m}}$

5. Which of the following graphs represents the variation of particle momentum and the associated de Broglie wavelength?

(A)



(B)



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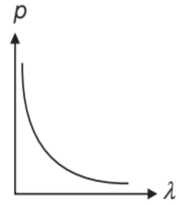
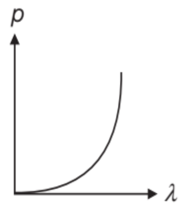


(D)



6. If Planck's constant is denoted by h and the electronic charge by e, experiments on photoelectric effect allow the determination of

(A) only h (B) only e

(C) both h and e (D) only $\dfrac{h}{e}$

7. The maximum energy of the electrons released in a photocell is independent of

(A) frequency of incident light

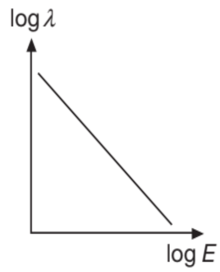
(B) intensity of incident light

(C) nature of cathode rays

(D) None of these

8. If the energy and wavelength of electron are E and λ, then the graph between $\log E$ and $\log\lambda$ will be

(A)



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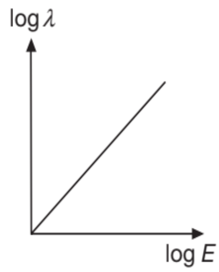

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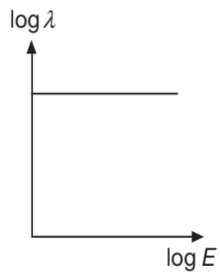
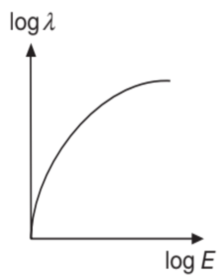


(D)



9. The total energy E of a sub-atomic particle of rest mass m_0 moving at non-relativistic speed v is

(A) $E=m_0c^2$ (B) $E=\dfrac{1}{2}m_0v^2$

(C) $E=m_0c^2+\dfrac{1}{2}m_0v^2$ (D) $E=m_0c^2-\dfrac{1}{2}m_0v^2$

10. An electron is 2000 times lighter than a proton. Both are moving such that their matter waves have a length of 1 Å. The ratio of their kinetic energy in approximation is

(A) 1 : 1 (B) 1 : 2000

(C) 2000 : 1 (D) 1 : 200

11. The de Broglie wavelength of a particle is approximately the same as that of a photon with the same energy.

(A) The energy of the particle is much greater than its rest energy.

(B) The energy of the particle is much less than its rest energy.

(C) The energy of the particle equals its rest energy.

(D) Data insufficient to arrive at a conclusion.

12. Two lumps of clay each of rest mass m_0, collide with a speed of $\frac{4}{5}c$ head on and stick together. The mass of the composite lump thus formed is

(A) $\frac{10}{3}m_0$ (B) $\frac{5}{3}m_0$

(C) $\frac{5}{6}m_0$ (D) $\frac{5}{12}m_0$

13. An electron moving with velocity $2\times10^7\ \text{ms}^{-1}$ describes a circle in a magnetic field of strength 2×10^{-2} T. If $\left(\frac{e}{m}\right)$ of electron is $1.76\times10^{11}\ \text{C kg}^{-1}$, then the diameter of the circle is nearly

(A) 1.1 m (B) 1.1 mm

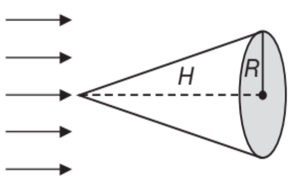
(C) 1.1 cm (D) 11 cm

14. The radiation emitted, when an electron jumps from $n = 3$ to $n = 2$ orbit is a hydrogen atom, falls on a metal to produce photoelectron. The electrons from the metal surface with maximum kinetic energy are made to move perpendicular to a magnetic field of $\frac{1}{320}$ T in a radius of 10^{-3} m. The work function of metal is

(A) 1.03 eV (B) 1.89 eV

(C) 0.86 eV (D) 2.03 eV

15. The radiation force experienced by a body exposed to radiation of intensity I assuming surface of body to be perfectly absorbing is



(A) $\frac{\pi R^2 I}{c}$ (B) $\frac{2\pi R^2 I}{c}$

(C) $\frac{4\pi R^2 I}{c}$ (D) None of these

16. A radiation of energy E falls normally on a perfectly reflecting surface. The change in momentum of radiation is

(A) $\frac{E}{c}$ (B) $\frac{2E}{c}$

(C) Ec (D) $\frac{E}{c^2}$

17. An electron, accelerated by a potential difference V, has de Broglie wavelength λ. If the electron is accelerated by a potential difference $4V$, its de Broglie wavelength will be

(A) 2λ (B) 4λ

(C) $\frac{\lambda}{2}$ (D) $\frac{\lambda}{4}$

18. The photoelectric work function of a metal is 1 eV. Light of wavelength $\lambda = 3000$ Å falls on it. The photoelectrons will come out with approximate speed equal to

(A) $10\ \text{ms}^{-1}$ (B) $10^2\ \text{ms}^{-1}$

(C) $10^4\ \text{ms}^{-1}$ (D) $10^6\ \text{ms}^{-1}$

19. A proton and an α-particle are accelerated through the same potential difference. The ratio of their de Broglie wavelengths is

(A) $\sqrt{2}$ (B) $\frac{1}{\sqrt{2}}$

(C) $2\sqrt{2}$ (D) 2

20. In an electron microscope if the potential is increased from 20 kV to 80 kV, the resolving power R of the microscope will become

(A) R (B) $2R$

(C) $4R$ (D) $\frac{R}{2}$

21. Boron has two isotopes ${}_5B^{10}$ and ${}_5B^{11}$. If the atomic weight of boron is 10.81, the ratio of ${}_5B^{10}$ to ${}_5B^{11}$ in nature is

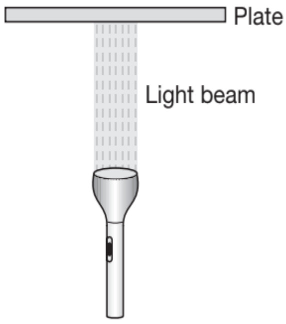
(A) $\frac{19}{81}$ (B) $\frac{20}{53}$

(C) $\frac{15}{10}$ (D) $\frac{10}{11}$

22. In photoelectric emission the number of electrons ejected per second is proportional to the

(A) intensity of light
(B) wavelength of light
(C) frequency of light
(D) work function of the material

23. A plate of mass 10 g is in equilibrium in air due to the force exerted by light beam on plate. Calculate power of beam. Assume plate is perfectly absorbing.



(A) 1.5×10^{7} W (B) 3×10^{7} W
(C) 4.5×10^{7} W (D) 6×10^{7} W

24. For a photon, the de Broglie relation is given by

(A) $\lambda = \frac{h}{mc}$ (B) $\lambda = \frac{h}{p}$
(C) $\lambda \to$ infinity (D) Data Insufficient

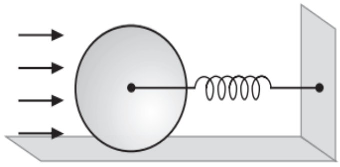
25. A desklamp illuminates a desk top with light of wavelength λ. The amplitude of this electromagnetic wave is E_0. Assuming illumination to be normally on the surface, the number of photons striking the desk per second per unit area N is

(A) $N = \frac{\lambda\varepsilon_0 E_0^2}{h}$ (B) $N = \frac{2\lambda\varepsilon_0 E_0^2}{h}$
(C) $N = \frac{\lambda\varepsilon_0 E_0^2}{2h}$ (D) Data Insufficient

26. A small metal plate (work-function W_0) is kept at a distance d from a singly ionised fixed ion. A monochromatic light beam is incident on the metal plate and photoelectrons are emitted. The maximum wavelength of light so that the photo-electrons may go round the ions along a circle is

(A) $\frac{8\pi\varepsilon_0 W_0 d + e^2}{8\pi hc\varepsilon_0 d}$ (B) $\frac{8\pi hc\varepsilon_0 d}{8\pi\varepsilon_0 W_0 d + e^2}$
(C) $\frac{2\left(\frac{hc}{W_0} - e^2\right)}{n}$ (D) $\frac{8\pi\varepsilon_0 d}{hceW_0}$

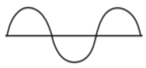
27. A perfectly reflecting body sphere in shape of radius R is placed on a path of parallel light beam of intensity I shown in figure. One end of a spring is attached to centre of sphere and the other end to a rigid wall as shown in figure. Assuming the sphere to be in equilibrium, the spring constant of spring to be K, then compression in spring is



(Neglect any thermal effect and friction is absent)

(A) $\frac{2I}{KC}\pi R^2$ (B) $\frac{I}{KC}\pi R^2$
(C) $\frac{I\pi R^2}{C}$ (D) None of these

28. The de-Broglie wave present in the fifth Bohr orbit is

(A) 

(B) 

(C) 

(D) 

29. The interatomic distance between atoms in a crystal is 2.8 Å. Then if such a crystal is used in Davisson-Germer experiment, the maximum order of diffraction that can be observed for a beam of electrons accelerated by 100 V shall be

(A) $n = 1$ (B) $n = 2$
(C) $n = 10$ (D) $n \to \infty$

30. The energy of a photon of wavelength λ is

(A) $hc\lambda$ (B) $\frac{hc}{\lambda}$
(C) $\frac{\lambda}{hc}$ (D) $\frac{h\lambda}{c}$

31. The work function of a metal in 4 eV. For the emission of photoelectrons of zero velocity from the metal surface, the wavelength of the incident radiation should be

(A) 1700 Å (B) 2700 Å
(C) 3100 Å (D) 5900 Å

32. Photoelectric effect is the phenomenon in which
(A) photons come out of a metal when it is hit by a beam of electrons
(B) photons come out of the nucleus of an atom under the action of an electric field.

(C) electrons come out of a metal with a constant velocity which depends on the frequency and intensity of incident radiation.
(D) electrons come out of a metal with different velocities not greater than a certain value which depends only on the frequency of the incident light and not on its intensity.

33. The photoelectric effect is the ejection of electrons from the surface of a metal when
(A) it is heated to a high temperature.
(B) electrons of suitable velocity strike it.
(C) radiation of suitable wavelength falls on it.
(D) it is placed in a strong electric field.

34. Matter waves are
(A) electromagnetic waves.
(B) transverse mechanical waves.
(C) longitudinal mechanical waves.
(D) neither electromagnetic nor mechanical waves.

35. A photon of wavelength 1000 Å has energy 12.3 eV. If light of wavelength 5000 Å, having intensity I, falls on a metal surface, the saturation current is 0.40 μA and the stopping potential is 1.36 V. The work function of the metal is
(A) 2.47 eV (B) 1.36 eV
(C) 1.10 eV (D) 0.43 eV

36. In PROBLEM 35, if the intensity of light is made $4I$, the stopping potential will become
(A) 1.36 V (B) 2.72 V
(C) 5.44 V (D) 21.76 V

37. In PROBLEM 35, if the intensity of light is made $4I$, the saturation current will become
(A) 0.4 μA (B) 0.8 μA
(C) 1.6 μA (D) 6.4 μA

38. In a photoemissive cell with exciting wavelength λ, the fastest electron has a speed v. If the exciting wavelength is changed to $\frac{3\lambda}{4}$, the speed of the fastest emitted electrons will be
(A) $v\sqrt{\frac{3}{4}}$ (B) $v\sqrt{\frac{4}{3}}$
(C) less than $v\sqrt{\frac{4}{3}}$ (D) greater than $v\sqrt{\frac{4}{3}}$

39. The de-Broglie wavelength of a molecule of thermal energy $k_B T$ (k_B = Boltzmann constant and T = absolute temperature), is
(A) $\lambda = \sqrt{\frac{h}{2mk_BT}}$ (B) $\frac{h}{\sqrt{2mk_BT}}$
(C) $h\sqrt{2mk_BT}$ (D) $\frac{h}{4m^2k_B^2T^2}$

40. A proton is accelerated through a potential V. The de Broglie wavelength associated with it is
(A) $\frac{12.27}{\sqrt{V}}$ Å (B) $\frac{0.287}{\sqrt{V}}$ Å
(C) $\frac{12.27}{\sqrt{V}}$ fm (D) $\frac{0.287}{\sqrt{V}}$ fm

41. In Davisson-Germer experiment Ni crystal acts as
(A) an ideal reflector
(B) three dimensional diffraction grating
(C) an ideal absorber
(D) two dimensional diffraction grating

42. Minimum light intensity that can be perceived by normal human eye is about 10^{-10} Wm^{-2}. What is the minimum number of photons of wavelength 660 nm that must enter the pupil in one second, for one to see the object? Area of cross-section of the pupil is 10^{-4} m^2?
(A) 3.318×10^3 (B) 1.453×10^3
(C) 3.318×10^4 (D) 1.453×10^5

43. The angle between the incident and the diffracted electron in the Davisson-Germer experiment is called as
(A) angle of incidence (B) angle of diffraction
(C) angle of scattering (D) none of the above

44. In Davisson-Germer experiment maximum intensity is observed at
(A) 50° and 54 volt (B) 54° and 50 volt
(C) 50° and 50 volt (D) 65° and 50 volt

45. A parallel beam of light of intensity I and cross section area S is incident on a plate at normal incidence. The photoelectric emission efficiency is 100%, the frequency of beam is ν and the work function of the plate is $\phi(h\nu > \phi)$. Assuming all the electrons are ejected normal to the plane and with same maximum possible speed. Calculate the net force exerted on the plate only due to striking of photons and subsequent emission of electrons
(A) $\frac{IS}{h\nu}\left(\frac{h}{\lambda}+\sqrt{m(h\nu-\phi)}\right)$
(B) $\frac{IS}{h\nu}\left(\frac{h}{\lambda}+\sqrt{2m(h\nu-\phi)}\right)$

(C) $\frac{hvS}{I}\left(\frac{h}{\lambda}+\sqrt{2m(hv-\phi)}\right)$

(D) None of these

46. In Davisson-Germer experiment, an electron beam of $60\ \text{eV}$ energy falls normally to the surface of the crystal and maximum intensity is obtained at an angle of $60°$ to the direction of incident beam. The inter-atomic distance in the lattice plane of the crystal is

(A) 18 Å (B) 3.6 Å
(C) 1.8 Å (D) 0.18 Å

47. The incorrect statement in connection with Davisson and Germer experiment is

(A) The inter-atomic distance in nickel crystal is of the order of the de-Broglie wavelength.
(B) Electrons of constant energy are obtained by the electron gun.
(C) Nickel crystal acts as a three dimensional diffracting grating.
(D) Davisson-Germer experiment is an interference experiment.

48. In Davisson-Germer experiment the relation between Bragg's angle ϕ and diffraction angle θ is

(A) $\theta = 90° - \phi$ (B) $\theta = \frac{90° - \phi}{2}$
(C) $\theta = 180° - \phi$ (D) $\phi = \left(\frac{180° - \theta}{2}\right)$

49. The ionization chamber used is Davisson-Germer experiment, acts as

(A) emitter (B) collector
(C) source (D) radiator

50. The distance between two consecutive atoms of the crystal lattice is 1.227 Å. The maximum order of diffraction of electrons accelerated through 10^4 V will be

(A) 10 (B) $\frac{1}{10}$
(C) 100 (D) $\frac{1}{100}$

51. The human eye can barely detect a yellow light (6000 Å) that delivers 1.7×10^{-18} watt to the retina. Nearly how many photons per second does the retina receive ?

(A) 50
(B) 5
(C) 500
(D) More than 5 million

52. The ratio of the specific charge of a proton to that of an α-particle is

(A) 1 : 4 (B) 1 : 2
(C) 4 : 1 (D) 2 : 1

53. A photosensitive surface is receiving light of wavelength 5000 Å at the rate of $10^{-7}\ \text{Js}^{-1}$. The number of photons received per second is

(A) 2.5×10^{12} (B) 2.5×10^{11}
(C) 2.5×10^{10} (D) 2.5×10^{9}

54. Photons of frequency ν fall on a metal surface for which the threshold frequency is ν_0. Then,

(A) all ejected electrons have the same kinetic energy $h(\nu - \nu_0)$.
(B) the ejected electrons have a distribution of kinetic energy from zero to $h(\nu - \nu_0)$.
(C) the most energetic electrons have kinetic energy $h\nu$
(D) the average kinetic energy of ejected electrons is $h\nu_0$.

55. When radiation of wavelength 3000 Å is incident on a photosensitive surface, the kinetic energy of electrons is 2.5 eV. The stopping potential for radiation of wavelength 1500 Å will be

(A) 2.5 V
(B) 5.0 V
(C) less than 5.0 V but more than 2.5 V
(D) more than 5.0 V

56. The de Broglie wavelength of a particle of mass m moving with a kinetic energy E is

(A) $\sqrt{\frac{h}{2mE}}$ (B) $\frac{h}{\sqrt{2mE}}$
(C) $\frac{h}{2mE}$ (D) $\frac{\sqrt{h}}{2mE}$

57. Two photons of energy 2.5 eV each are incident on a metal plate whose work function is 4.0 eV, then the number of electrons emitted from the metal surface will be

(A) one
(B) two
(C) None of these
(D) more than two

58. Of the following moving with same momentum, the one which has largest wavelength is

(A) an electron.
(B) a proton.
(C) an α-particle.
(D) all have same de-Broglie wavelength.

59. The maximum velocity of an electron emitted by light of wavelength λ incident on the surface of a metal of work-function ϕ is

(A) $\sqrt{\dfrac{2(hc+\lambda\phi)}{m\lambda}}$ (B) $\dfrac{2(hc-\lambda\phi)}{m}$

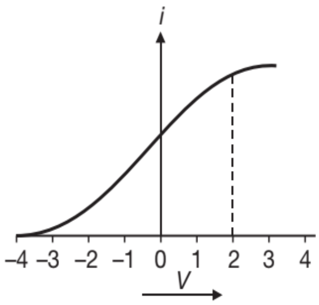
(C) $\sqrt{\dfrac{2(hc-\lambda\phi)}{m\lambda}}$ (D) $\sqrt{\dfrac{2(h\lambda-\phi)}{m}}$

where $h=$ Planck's constant, $m=$ mass of electron and $c=$ speed of light

60. An α–particle is accelerated through a potential difference of 200 V. The increase in its kinetic energy in electron volt will be

(A) 100 eV (B) 200 eV
(C) 400 eV (D) 800 eV

61. Figure represents the graph of photo current i versus applied voltage (V). The maximum energy of the emitted photoelectrons is

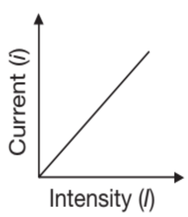


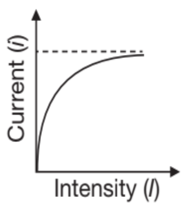
(A) 2 eV (B) 4 eV
(C) 0 eV (D) 4 J

62. Which one of the following graphs represents correctly the variation of photoelectric current (i) with intensity (I) of incident radiations

(A)


(B)


(C)


(D)


63. The potential difference between the cathode and anode in a cathode ray tube is V. Then the speed acquired by the electrons is proportional to

(A) V (B) $\sqrt{V}$
(C) V^2 (D) $V^{3/2}$

64. The duration of a laser pulse is 10^{-8} s. The uncertainty in its energy will be

(A) 6.6×10^{-26} J (B) 6.6×10^{-34} J
(C) 6.6×10^{-42} J (D) $\dfrac{1}{6.6}\times10^{26}$ J

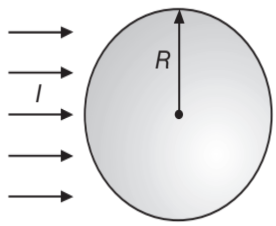
65. Which one of the following statements about photons is incorrect?

(A) Rest mass of a photon is zero
(B) Momentum of a photon of frequency ν is $\dfrac{h\nu}{c}$
(C) Energy of a photon of frequency ν is $h\nu$
(D) Photons exert no pressure

66. A parallel beam of uniform, monochromatic light of wavelength 2640 Å has an intensity of $100\ \text{Wm}^{-2}$. The number of photons in $1\ \text{mm}^3$ of this radiation are

(A) 222 (B) 335
(C) 442 (D) 555

67. Consider a sphere of radius R exposed to radiation of intensity I as shown in figure. If surface of sphere is partially reflection and reflection coefficient is 0.3, then radiation force experienced is



(A) $\dfrac{\pi R^2 I}{c}$ (B) $\dfrac{1.7\pi R^2 I}{c}$
(C) $\dfrac{0.3\pi R^2 I}{c}$ (D) None of these

68. A charge particle q of mass m is projected along the y-axis at $t=0$ from origin with a velocity v_0. If a uniform electric field E also exists along the x-axis, then the time at which de-Broglie wavelength of the particle becomes half of the initial value is

(A) $\dfrac{mv_0}{qE}$ (B) $2\left(\dfrac{mv_0}{qE}\right)$
(C) $\sqrt{3}\left(\dfrac{mv_0}{qE}\right)$ (D) $3\left(\dfrac{mv_0}{qE}\right)$

69. Two electrons are moving with the same speed v. One electron enters a region of uniform electric field while the other enters a region of uniform magnetic field, then after sometime if the de-Broglie wavelengths of the two are λ_1 and λ_2, then

(A) $\lambda_1=\lambda_2$ (B) $\lambda_1>\lambda_2$
(C) $\lambda_1<\lambda_2$ (D) $\lambda_1>\lambda_2$ or $\lambda_1<\lambda_2$

70. An electromagnetic radiation of wavelength λ has the same momentum as an electron moving with a speed 2×10^5 ms^{-1}.

(A) $\lambda = 2.64$ nm (B) $\lambda = 1.64$ nm
(C) $\lambda = 3.64$ nm (D) $\lambda = 4.64$ nm

71. Let K_1 be the maximum kinetic energy of photo-electrons emitted by light of wavelength λ_1 and K_2 corresponding to wavelength λ_2. If $\lambda_1 = 2\lambda_2$ then

(A) $2K_1 = K_2$ (B) $K_1 = 2K_2$
(C) $K_1 < \frac{K_2}{2}$ (D) $K_1 > 2K_2$

72. Solar constant of the sun is $\sigma = 8.106\times10^4$ Jmin^{-1}m^{-2} and average sun earth distance is 1.5×10^8 km. The yearly loss in the mass of the sun is

(A) 13.8×10^{17} kg (B) 1.38×10^{19} kg
(C) 1.38×10^{17} kg (D) 13.8×10^{20} kg

73. A photon strikes a free electron at rest and is scattered straight backward. If the speed of electron after collision is αc, where $\alpha \ll 1$ then,

(A) electron's kinetic energy is a fraction α of photon's initial energy.
(B) electron's kinetic energy is a fraction $\frac{1}{\alpha}$ of photon's initial energy.
(C) electron's kinetic energy is a fraction α^2 of photon's initial energy.
(D) electron's kinetic energy is a fraction $\frac{1}{\alpha^2}$ of photon's initial energy.

74. Which one of the following does not fit into the group?

(A) Photon (B) Graviton
(C) Proton (D) Meson

75. Both the frequency and the intensity of a beam of light falling on the surface of photoelectric material are increased by a factor of two. This will

(A) increase both, the maximum kinetic energy of the photo-electrons, as well as photoelectric saturation current by a factor of two.
(B) increase the maximum kinetic energy of the photo-electrons by a factor greater than two and would increase the photoelectric saturation current by a factor of two.
(C) increase the maximum kinetic energy of the photoelectrons by a factor greater than two and will have no effect on the magnitude of the photoelectric saturation current produced.
(D) increase the maximum kinetic energy of the emitted photo-electrons by a factor of two but will have no effect on the saturation photoelectric current.

76. Two photons approach each other. The relative velocity of approach is

(A) $\frac{c}{2}$ (B) c
(C) $2c$ (D) $4c$

77. 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 $\left(\frac{\lambda_1}{\lambda_2}\right)$ is

(A) $\frac{1}{4}$ (B) $\frac{1}{2}$
(C) 1 (D) 2

78. A small ball is projected with initial speed u and at an angle θ with horizontal from ground. The de-Broglie wavelength of ball at the moment its velocity vector becomes perpendicular to initial velocity vector is

(A) $\frac{h}{mu}$ (B) $\frac{h}{mu\sin\theta}$
(C) $\left(\frac{h}{mu}\right)\tan\theta$ (D) $\frac{h}{mu\cos\theta}$

79. The force exerted by a photon of intensity 1.4 kWm^{-2} if it falls on a perfect absorber of radius 2 m is

(A) 2.35×10^{-4} N (B) 10^8 N
(C) 8.35×10^4 N (D) 8.8×10^{-8} N

80. A point source of radiation power P is placed on the axis of completely absorbing disc. The distance between the source and the disc is 2 times the radius of the disc. Find the force that light exerts on the disc

(A) $\frac{P}{c}$ (B) $\frac{P}{5c}$
(C) $\frac{P}{10c}$ (D) $\frac{P}{20c}$

81. Photoelectrons are emitted with maximum kinetic energy E from a metal surface when light of frequency v falls on it when light of frequency v' falls on the same metal, the maximum kinetic energy of emitted photoelectrons is found to be $2E$, then v' is

(A) $v' = v$ (B) $v' = 2v$
(C) $v' > 2v$ (D) $v' < 2v$

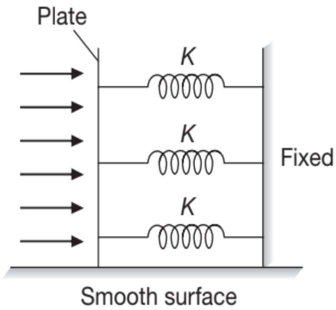
82. A material particle with a rest mass m_0 is moving with speed of light c. The de-Broglie wavelength associated is given by

(A) $\frac{h}{m_0 c}$ (B) $\frac{m_0 c}{h}$
(C) zero (D) ∞

83. Light of two different frequencies whose photons have energies 1 eV and 2.5 eV successively illuminate a metal of work function 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

84. Light of intensity I is incident normally on a perfectly reflecting plate of area A kept in a gravity free space. If the photons strike the plate symmetrically and initially the springs are in their natural lengths, then the maximum compression in the springs is



(A) $\frac{IA}{KC}$ (B) $\frac{2IA}{3KC}$
(C) $\frac{3IA}{KC}$ (D) $\frac{4IA}{3KC}$

85. The work function of a metallic surface is 5.01 eV. Photoelectrons are emitted when light of wavelength 2000 Å falls on it. The potential difference required to stop the fastest photoelectrons is

$(h = 4.14 \times 10^{-15}\ \text{eVs})$

(A) 1.2 V (B) 2.4 V
(C) 3.6 V (D) 4.8 V

86. A proton, accelerated through a potential difference V has a certain de Broglie wavelength. In order to have the same de Broglie wavelength, an α-particle must be accelerated through a potential difference

(A) $4V$ (B) $8V$
(C) $\frac{V}{4}$ (D) $\frac{V}{8}$

87. Radiation of frequency 1.5 times the threshold frequency is incident on a photosensitive material. If the frequency of incident radiations is halved and the intensity is doubled, the number of photoelectron ejected per second becomes

(A) zero
(B) half of its initial value
(C) one fourth the initial value
(D) three fourth the initial value

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

(A) 9.61×10^{14} (B) 4.12×10^{13}
(C) 1.51×10^{12} (D) 2.13×10^{11}

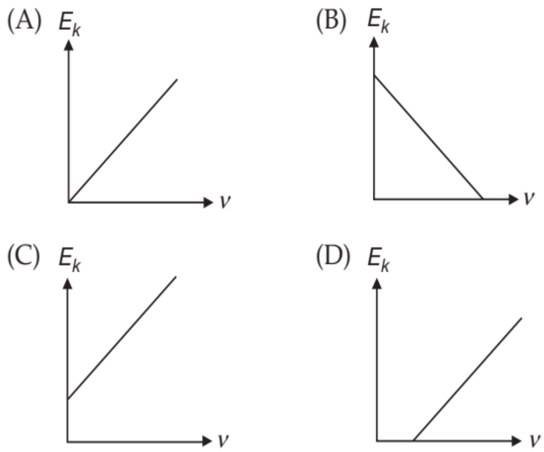
89. A proton and an α-particle are injected into a uniform electric field at right angles to the direction of field with equal kinetic energy. Then

(A) the proton trajectory will be less curved than α-particle trajectory.
(B) the α-particle trajectory will be less curved than proton trajectory.
(C) both the trajectories will be equally curved.
(D) both trajectories will be straight.

90. de Broglie waves are associated with

(A) moving charged particles only.
(B) moving neutral particles only.
(C) all moving particles.
(D) all particles whether in motion or at rest.

91. The maximum kinetic energy (E_K) of photoelectrons varies with the frequency (ν) of the incident radiation as



92. Stopping potential for photoelectrons

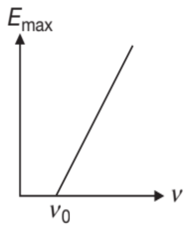
(A) does not depend on the frequency of the incident light.
(B) does not depend on the nature of cathode material.
(C) depends on both the frequency of the incident light and the nature of the cathode material.
(D) depends on the intensity of the incident light.

93. A particle of mass 10^{-31} kg is moving with a speed of $10^5\ \text{ms}^{-1}$. The de Broglie wavelength of the particle is

(A) 6.63×10^{-8} m (B) 6.63 Å
(C) 66.3 Å (D) 6.63×10^{-7} m

94. A moving particle is associated with a wave packet or group of waves. The group velocity is equal to
(A) velocity of light
(B) velocity of sound
(C) velocity of particle
(D) $\dfrac{1}{\text{particle velocity}}$

95. The maximum kinetic energy $(E_{\max})$ of photoelectrons emitted in a photoelectric cell varies with frequency (ν) as shown in the graph. The slope of the graph is equal to



(A) charge of the electron
(B) $\dfrac{e}{m}$ of the electron
(C) work function of the emitter
(D) Planck's constant

96. A photon of frequency ν is incident on a metal surface whose threshold frequency is ν_0. The maximum kinetic energy of the emitted electron will be
(A) $h(\nu-\nu_0)$ (B) $h(\nu+\nu_0)$
(C) $\frac{1}{2}h(\nu-\nu_0)$ (D) $\frac{1}{2}h(\nu+\nu_0)$

97. A stream of photons impinging normally on a completely absorbing screen in vacuum exerts a pressure P. If I is the irradiance then,
(A) $P=\dfrac{2I}{c}$ (B) $P=Ic$
(C) $P=\dfrac{I}{c}$ (D) $P=2Ic$

98. An electron and a photon have same wavelength. It p is the momentum of electron and E the energy of photon. The magnitude of $\dfrac{p}{E}$ in SI unit is
(A) $\dfrac{1}{2c}$ (B) $\dfrac{1}{c}$
(C) $\dfrac{2}{c}$ (D) None of these

99. A metal plate is exposed to light with wavelength λ. It is observed that electrons are ejected from the surface of the plate. When a retarding uniform electric field E is imposed, no electron can move away from the plate farther than a certain distance d. Then the threshold wavelength λ_0 for the material of plate is (e is the electronic charge, h is Planck's constant and c is the speed of light)
(A) $\lambda_0=\left(\dfrac{1}{\lambda}-\dfrac{hc}{eEd}\right)^{-1}$ (B) $\lambda_0=\left(\dfrac{1}{\lambda}-\dfrac{eEd}{hc}\right)^{-1}$
(C) $\lambda_0=\lambda-\dfrac{hc}{eEd}$ (D) $\lambda_0=\lambda-\dfrac{eEd}{hc}$

100. 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) $N=\dfrac{P\lambda d^2t}{hcl^2}$ (B) $N=\dfrac{4P\lambda d^2t}{hcl^2}$
(C) $N=\dfrac{P\lambda d^2t}{4hcl^2}$ (D) $N=\dfrac{P\lambda d^2t}{16hcl^2}$

101. When a metallic surface is illuminated by a monochromatic light of wavelength λ, the stopping potential for photoelectric current is $3V_0$. When the same surface is illuminated by light of wavelength 2λ, the stopping potential is V_0. The threshold wavelength for this surface for photoelectric effect is
(A) 6λ (B) $\dfrac{4\lambda}{3}$
(C) 4λ (D) 8λ

102. The momentum of a photon of an electromagnetic radiation is 3.3×10^{-29} kgms^{-1}. The frequency of the associated waves is $\left(h=6.6\times10^{-34}\text{ Js},\ c=3\times10^{8}\text{ ms}^{-1}\right)$
(A) 3.0×10^{3} Hz (B) 6.0×10^{3} Hz
(C) 7.5×10^{12} Hz (D) 1.5×10^{13} Hz

103. If the wavelength of incident radiation in a photoelectric experiment is decreased then
(A) the photoelectric current will decrease.
(B) the photoelectric current will increase.
(C) the stopping potential will decrease.
(D) the stopping potential will increase.

104. The threshold wavelength for a photosensitive surface is 6000 Å and the wavelength of incident light is 5000 Å. Then the maximum energy of emitted electrons would be

(A) 0.041 eV (B) 0.41 eV
(C) 4.1 eV (D) 41 eV

105. An electron of mass m and charge e initially at rest gets accelerated by a constant electric field E. The rate of change of de-Broglie wavelength of this electron at time t, ignoring relativistic effects

(A) $-\dfrac{h}{eEt^2}$ (B) $-\dfrac{eht}{E}$

(C) $-\dfrac{mh}{eEt^2}$ (D) $-\dfrac{h}{eE}$

106. Of the following, the one which has the largest de Broglie wavelength for the same speed is
(A) electron (B) proton
(C) α-particle (D) oxygen atom

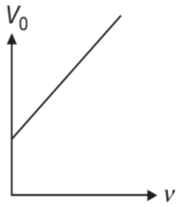
107. A beam of light has an power of $144\ \text{W}$ equally distributed among three wavelength of $4100\ \text{Å}$, $4960\ \text{Å}$ and $6200\ \text{Å}$. The beam is incident at an angle of incidence of $60°$ on an area of $1\ \text{cm}^2$ of a clean sodium surface, having a work function of $2.3\ \text{eV}$. Assuming that there is no loss of light by reflection and that each energetically capable photon ejects a photoelectron, find the saturation photocurrent. (Take $hc = 12400\ \text{eVÅ}$)
(A) 1.76 mA (B) 0.88 mA
(C) 3.52 mA (D) None of these

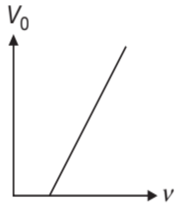
108. A small photocell is placed at a distance of $4\ \text{m}$ from a photosensitive surface. When light falls on the surface the current is 5 mA. If the distance of cell is decreased to $1\ \text{m}$, the current will become

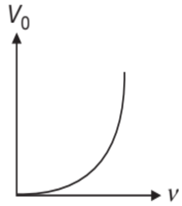
(A) 1.25 mA (B) $\left(\dfrac{5}{16}\right)$ mA
(C) 20 mA (D) 80 mA

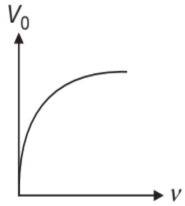
109. Einstein's photoelectric equation is $E_K = h\nu - \phi$. In this equation E_K refers to
(A) kinetic energy of all the emitted electrons.
(B) mean kinetic energy of emitted electrons.
(C) maximum kinetic energy of emitted electrons.
(D) minimum kinetic energy of emitted electrons.

110. In photoelectric effect, the graph showing the variation of cut-off voltage (V_0) with the frequency of incident radiation (ν) is

(A)


(B)


(C)


(D)


111. An electron is accelerated through a potential difference of 100 V. Its kinetic energy will be
(A) 100 J (B) 100 erg
(C) 100 eV (D) 100 MeV

112. If 5% of the energy supplied to a bulb is radiated as visible light, the number of visible quanta emitted per second by a $100\ \text{W}$ bulb, assuming the wavelength of visible light to be $5.6 \times 10^{-5}\ \text{cm}$, is
(A) 1.4×10^{19} (B) 1.4×10^{20}
(C) 2×10^{19} (D) 2×10^{20}

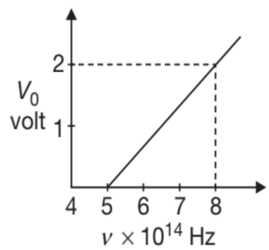
113. A neutron is confined to a nucleus of size $10^{-14}\ \text{m}$. The minimum momentum of the electron may be
(A) $6.6 \times 10^{-20}\ \text{kgms}^{-1}$ (B) $3.3 \times 10^{-20}\ \text{kgms}^{-1}$
(C) $3.3 \times 10^{-48}\ \text{kgms}^{-1}$ (D) $6.6 \times 10^{-48}\ \text{kgms}^{-1}$

114. A point source of radiation power P is placed on the axis of an ideal plane mirror. The distance between the source and the mirror is n times the radius of the mirror. Find the force that light exerts on the mirror

(A) $\dfrac{2P}{c(n^2+1)}$ (B) $\dfrac{P(n^2+1)}{2c}$

(C) $\dfrac{P}{2c(n^2+1)}$ (D) $\dfrac{P}{4c(n^2+1)}$

115. The stopping potential (V_0) versus frequency plot of a substance is shown in figure The threshold wavelength is



(A) $5 \times 10^{14}\ \text{m}$
(B) $6000\ \text{Å}$
(C) $5000\ \text{Å}$
(D) cannot be estimated from given data

116. The energy of incident photon is 12.375 eV while the energy of scattered photon is $9.375\ \text{eV}$. Then the kinetic energy of recoil electron is

(A) 3 eV (B) less than 3 eV
(C) more than 3 eV (D) 21.75 eV

117. When electrons are accelerated through potential difference of V volt, the de-Broglie wavelength associated is given by

(A) $\lambda = \sqrt{\frac{150}{V}}$ Å (B) $\lambda = \sqrt{\frac{150}{V}}$ m

(C) $\lambda = \frac{150}{\sqrt{V}}$ Å (D) $\lambda = \frac{\sqrt{150}}{V}$ Å

118. An electron and a proton are accelerated through the same potential. If their masses are m_e and m_p respectively, then the ratio of their de Broglie wavelength is

(A) 1 (B) $\sqrt{\frac{m_e}{m_p}}$

(C) $\frac{m_p}{m_e}$ (D) $\sqrt{\frac{m_p}{m_e}}$

119. A particle of mass 1 g is located in a box of size 2 cm. The uncertainty in the momentum of the electron will be

(A) 3.3×10^{-32} kgms^{-1} (B) 6.6×10^{-32} kgms^{-1}

(C) 3.3×10^{-33} kgms^{-1} (D) 6.6×10^{-34} kgms^{-1}

120. If E_1, E_2, E_3 are the respective kinetic energies of an electron, an alpha-particle and a proton, each having the same de-Broglie wavelength, then

(A) $E_1 > E_3 > E_2$ (B) $E_2 > E_3 > E_1$

(C) $E_1 > E_2 > E_3$ (D) $E_1 = E_2 = E_3$

121. The eye can detect 5×10^4 photons/m^{2}s of light of wavelength 500 nm. The ear can detect 10^{-13} Wm^{-2}. As a power detector, which is more sensitive?

(A) Sensitivity of eye is one fifth of the ear
(B) Sensitivity of eye is five times that of ear
(C) Both are equally sensitive
(D) Eye cannot be used as power detector

122. The kinetic energy of electron is E, when the incident light has wavelength λ. To increase the K.E. to $2E$, the incident light must have wavelength

(A) $\frac{hc}{E\lambda - hc}$ (B) $\frac{hc\lambda}{E\lambda + hc}$

(C) $\frac{h\lambda}{E\lambda + hc}$ (D) $\frac{hc\lambda}{E\lambda - hc}$

123. We wish to observe an object which is 2.5 Å in size. The minimum energy photon that can be used is

(A) 5 keV (B) 8 keV
(C) 10 keV (D) 12 keV

124. A certain mass of ice at 0° C melts into water at 0° C and there by gains 1 kg mass. If initial mass of ice is m_0 then,

(A) $m_0 = 2.69 \times 10^{11}$ kg (B) $m_0 = 1$ kg

(C) $m_0 = 2.69 \times 10^{10}$ kg (D) $m_0 = 9 \times 10^{16}$ kg

125. A star of mass M_0, radius R_0 contracts to radius R. Energy radiated by the star assuming uniform density in each case while temperature remains unchanged is

(A) M_0c^2 (B) $M_0c^2\left[1-\left(\frac{R}{R_0}\right)^2\right]$

(C) $M_0c^2\left(1-\frac{R}{R_0}\right)$ (D) $M_0c^2\left[1-\left(\frac{R}{R_0}\right)^3\right]$

126. The number of red photons $(\lambda = 663 \text{ nm})$ that must strike a totally reflecting screen per second at normal incidence so that a force of 1N is exerted on the screen is

(A) $n = 5 \times 10^{23}$ (B) $n = 5 \times 10^{24}$

(C) $n = 5 \times 10^{25}$ (D) $n = 5 \times 10^{26}$

127. A 20 amu atom emits photon of 6.6 Å while making a transition from excited state to ground state. The recoil energy of the atom will be

(A) 1.5×10^{-23} J (B) 3.5×10^{-23} J

(C) 5.1×10^{-23} J (D) 7.5×10^{-23} J

128. How many red photon (wavelength λ) must strike a totally reflecting screen per second at normal incidence, if the exerted force is to be 1 N?

(A) $\frac{\lambda}{h}$ (B) $\frac{2\lambda}{h}$

(C) $\frac{\lambda}{2h}$ (D) infinity

129. The surface of a metal is illuminated with the light of 400 nm. The kinetic energy of the ejected photoelectrons was found to be 1.68 eV. The work function of the metal for $hc = 1240$ eV-nm is

(A) 3.09 eV (B) 1.41 eV
(C) 1.51 eV (D) 1.68 eV

130. A cathode of a photoelectric cell is changed such that the work function changes from W_1 to W_2 $(W_1 < W_2)$. If the current before and after changes are

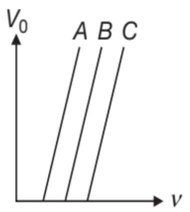
I_1 and I_2 all other conditions remaining unchanged, then (assuming $h\nu > W_2$)

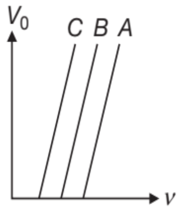
(A) $I_1 = I_2$ (B) $I_1 < I_2$
(C) $I_1 > I_2$ (D) $I_1 < I_2 < 2I_1$

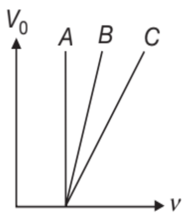
131. The momentum of a photon of frequency ν is

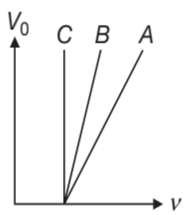
(A) $\frac{h\nu}{c^2}$ (B) $\frac{h\nu}{c}$
(C) $h\nu c$ (D) $h\nu c^2$

132. The work functions for three different metals A, B and C are ϕ_A, ϕ_B and ϕ_C respectively with $\phi_A > \phi_B > \phi_C$. The graphs between stopping potential (V_0) and frequency ν of incident radiation for them would look like

(A)


(B)


(C)


(D)


133. The work function of a certain metal is $\frac{hc}{\lambda_0}$. When a monochromatic light of wavelength $\lambda < \lambda_0$ is incident such that the plate gains a total power P. If the efficiency of photoelectric emission is $\eta\%$ and all the emitted photoelectrons are captured by a hollow conducting sphere of radius R already charged to potential V, then neglecting any interaction between plate and the sphere, expression of potential of the sphere at time t is

(A) $V + \frac{100\eta\lambda Pet}{4\pi\varepsilon_0 Rhc}$ (B) $V + \frac{\eta\lambda Pet}{4\pi\varepsilon_0 Rhc}$
(C) V (D) $\frac{\lambda Pet}{4\pi\varepsilon_0 Rhc}$

134. In order to increase the kinetic energy of ejected photoelectrons, there should be an increase in
(A) intensity of radiation.
(B) wavelength of radiation.
(C) frequency of radiation.
(D) both wavelength and intensity of radiation.

135. Which of the following arrangements corresponds to decreasing order of specific charge?
(A) Electron, proton, α-particle
(B) Proton, α-particle, electron
(C) α-particle, electron, proton
(D) Electron, α-particle, proton

136. A photoelectric cell is illuminated by a small bright source of light placed at 1 m. If the same source of light is placed 2 m away, the electrons emitted by the cathode
(A) each carries one quarter of its previous momentum.
(B) each carries one quarter of its previous energy.
(C) are half the previous number.
(D) are one quarter of the previous number.

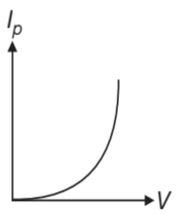
137. Radiation pressure on any surface is
(A) dependent on wavelength of the light used
(B) dependent on nature of surface and intensity of light used
(C) dependent on frequency and nature of surface
(D) depends on the nature of source from which light is coming and on nature of surface on which it is falling

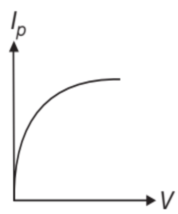
138. Light of frequency 1.5 times the threshold frequency is incident on a photo-sensitive material. If the frequency is halved and the intensity is doubled, the photoelectric current becomes
(A) four times (B) double
(C) half (D) zero

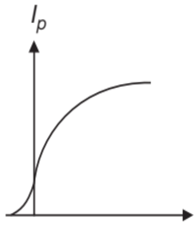
139. The ratio of the de Broglie wavelengths of a proton and an α-particle will be $1:2$ if their
(A) kinetic energies are in the ratio $1:8$
(B) kinetic energies are in the ratio $8:1$
(C) velocities are in the ratio $1:8$
(D) velocities are in the ratio $8:1$

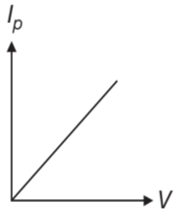
140. Cathode rays moving with same velocity v describe an approximate circular path of radius r metre in an electric field of strength x volt metre^{-1}. If the speed of the cathode rays is doubled to $2v$, the value of electric field needed so that the rays describe the same approximate circular path (volt metre^{-1}) is
(A) $2x$ (B) $3x$
(C) $4x$ (D) $6x$

141. Which of the following graphs gives the variation of photoelectric current (I_p) with the voltage (V) applied to the electrodes of a photo cell?

(A)


(B)


(C) 

(D) 

142. An electron with speed v and a photon with a speed c have the same de-Broglie wavelength. If the K.E. and momentum of electrons is E_e and P_e and that of photon is E_{ph} and P_{ph} respectively, then the correct statement is

(A) $\frac{E_e}{E_{ph}} = \frac{2c}{v}$ (B) $\frac{E_e}{E_{ph}} = \frac{v}{2c}$

(C) $\frac{P_e}{P_{ph}} = \frac{2c}{v}$ (D) None of these

143. The energy of a photon corresponding to the visible light of maximum wavelength is approximately

(A) 1 eV (B) 1.6 eV

(C) 3.2 eV (D) 7 eV

144. Planck's work was connected with

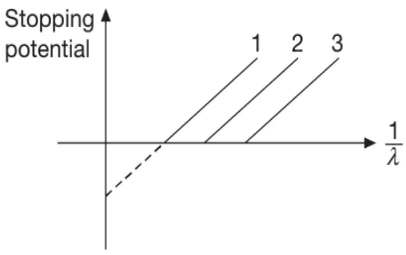
(A) wave nature of matter

(B) photoelectric effect

(C) structure of atom

(D) quantum nature of radiation.

145. The graph shows stopping potential versus $\frac{1}{\text{wavelength}}$ for three metals, then



(A) Planck's constant for metal (1) is greatest

(B) Work function for metal (3) is greatest

(C) Threshold frequency for metal (1) is greatest

(D) Threshold wavelength is maximum for metal (3)

146. Number of identical photons incident on a perfectly black body of mass m kept at rest on smooth horizontal surface. Then the acceleration of the body if n number of photons incident per sec. is (Assume wavelength of photon to be λ)

(A) $\frac{nh}{2\pi\lambda m}$ (B) $\frac{nh}{\lambda m}$

(C) $\frac{2\pi nh}{\lambda m}$ (D) $\frac{\lambda m}{nh}$

147. A radio transmitter operates at a frequency of 880 kHz and a power of 10 kW. The number of photons emitted per second is

(A) 1.71×10^{31} (B) 1327×10^{34}

(C) 13.27×10^{34} (D) 13.27×10^{44}

148. The largest momentum we can expect for a microwave photon is

(A) 6.6×10^{-27} kgms^{-1} (B) 6.6×10^{-34} kgms^{-1}

(C) 6.6×10^{-31} kgms^{-1} (D) 6.6×10^{-30} kgms^{-1}

149. An electron is moving with a velocity of $\frac{c}{10}$. The de-Broglie wavelength associated with it is

(A) 0.48×10^{-10} m (B) 0.24×10^{-10} Å

(C) 0.24×10^{-10} m (D) 1.24×10^{-10} m

150. The kinetic energy of the body is twice the rest mass energy. The ratio of the relativistic mass of the body to its rest mass is

(A) 1 (B) 2

(C) 3 (D) infinite

151. The number of complete de-Broglie wavelengths associated with the electron in nth orbit of hydrogen atom is

(A) n (B) n^2

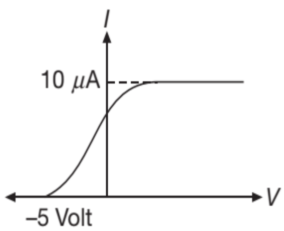
(C) $\frac{1}{n}$ (D) n^4

152. In a photoelectric cell, the current stops when the collecting plate is one volt negative with respect to the emitting metal. The maximum kinetic energy of the photoelectrons is

(A) 1 erg (B) 1 J

(C) 1.6×10^{-19} J (D) 1.6×10^{-19} eV

153. In the photoelectric experiment, if we use a monochromatic light, the I-V curve is as shown. If work function of the metal is 2 eV, estimate the power of light used. (Assume efficiency of photo emission $=10^{-3}$%, i.e. number of photoelectrons emitted are 10^{-3}% of number of photons incident on metal.)

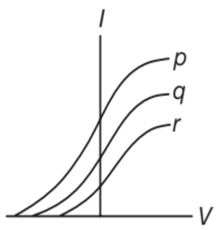


(A) 2 W (B) 5 W

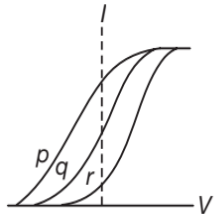
(C) 7 W (D) 10 W

154. Photoelectric effect experiments are performed using three different metal plates p, q and r having work functions $\phi_p = 2\text{ eV}$, $\phi_q = 2.5\text{ eV}$ and $\phi_r = 3\text{ eV}$, 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

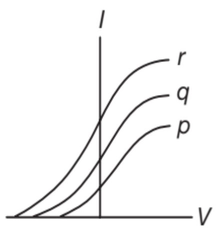
(A)



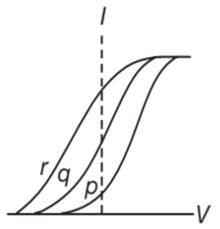
(B)



(C)



(D)



155. The energy associated with a thermal neutron is of the order of
(A) 10 KeV
(B) 1 KeV
(C) 0.1 MeV
(D) 0.01 MeV

156. A proton, a deutron and an alpha particle are accelerated through potentials of V, $2V$ and $4V$ respectively. Their velocities will bear a ratio
(A) $1:1:1$
(B) $1:\sqrt{2}:1$
(C) $\sqrt{2}:1:1$
(D) $1:1:\sqrt{2}$

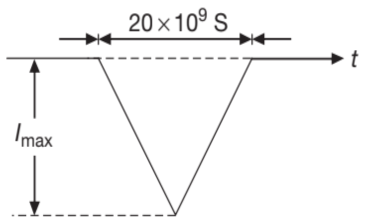
MULTIPLE CORRECT CHOICE TYPE QUESTIONS

This section contains Multiple Correct Choice Type Questions. Each question has four choices (A), (B), (C) and (D), out of which ONE OR MORE is/are correct.

1. The maximum kinetic energy of photoelectrons ejected from a photometer when it is irradiated with radiation of wavelength 400 nm is 1 eV. If the threshold energy of the metal surface is 1.9 eV. Select the correct statement(s).
(A) The maximum K.E. of photoelectrons when it is irradiated with 500 nm photon will be 0.42 eV
(B) The maximum K.E. of photoelectrons when it is irradiated with 500 nm photon will be 1.725 eV
(C) The longest wavelength which will eject photoelectrons is nearly 6100 Å
(D) The value of hc is 11600 eVÅ

2. A collimated beam of light of flux density 30 kWm^{-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) $P = 10^{-3}\text{ Nm}^{-2}$
(B) $P = 10^{-4}\text{ Nm}^{-2}$
(C) $\Delta p = 10^{-4}\text{ kgms}^{-1}$
(D) $\Delta p = 10^{-5}\text{ kgms}^{-1}$

3. A photomultiplier tube is to be used to detect light pulses each of which consists of a small but fixed number of photons. The average photoelectric efficiency is 10%. That is photon has 10% probability of causing the emission of a detectable photoelectron. Assume the photomultiplier gain is 10^6 and that the output current as a function of time (in nanosecond) can be approximated as shown in figure.

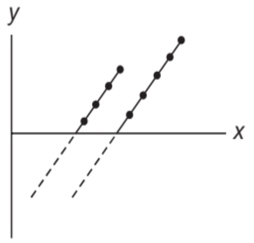


I_{max} when averaged over many pulses is $80\ \mu\text{A}$. Then which of the following statements is/are true.
(A) The charge carried by one pulse is $8\times10^{-13}\text{ C}$
(B) Number of photoelectrons emitted per light pulse is 5
(C) Number of photons in one light pulse is 50
(D) Number of electrons carried by one pulse is 5×10^5

4. Light from a monochromatic source is incident normally on a small photo sensitive surface S having work function ϕ. If power of the source is W and a is the distance between the source and S, then

(A) the number of photons striking the surface per unit time will be $\left(\frac{W\lambda S}{4\pi hca^2}\right)$
(B) the maximum energy of the emitted electrons will be $\left(\frac{hc}{\lambda}-\phi\right)$
(C) the stopping potential needed to stop the most energetic photons will be $\frac{e}{\lambda}(hc-\lambda\phi)$
(D) photo emission occurs only if $0 \le \lambda \le \frac{hc}{\phi}$

5. For photoelectric phenomenon, an experimenter plots a graph as shown in figure.



Which of the following statement(s) is/are correct?
(A) x-axis shows wavelength of light used
(B) y-axis shows the kinetic energy of the slowest among the electrons ejected
(C) the intercept on the x-axis is proportional to the work function of the cathode
(D) the two graph lines for different cathodes are always parallel

6. When ultraviolet radiation is incident on a surface, no photoelectrons are emitted. If another beam causes photoelectrons to be emitted from the surface, it may consist of
(A) radio waves
(B) infrared rays
(C) X-rays
(D) gamma rays

7. When the intensity of a light source is increased,
(A) the number of photons emitted by the source in unit time increases
(B) the total energy of the photons emitted per unit time increases
(C) more energetic photons are emitted
(D) faster photons are emitted

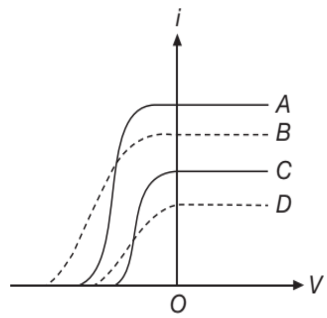
8. Light rays are incident on an opaque sheet. The correct statement(s) is/are
(A) Light rays exert a force on the sheet
(B) Light rays transfer an energy to the sheet
(C) Light rays transfer momentum to the sheet
(D) Light rays transfer impulse to the sheet

9. According to Heisenberg's Uncertainty Principle,
(A) $\Delta x \Delta p \ge \frac{h}{4\pi}$ (B) $\Delta E \Delta t \ge \frac{h}{4\pi}$
(C) $\Delta\theta \Delta L \ge \frac{h}{4\pi}$ (D) $\Delta x \Delta v \ge \frac{h}{4\pi m}$
where the symbols bear the usual meaning.

10. In which of the following situations, the heavier of the two particles will have a smaller de-Broglie wavelength.
(A) The particles move with the same speed
(B) The particles move with the same linear momentum
(C) The particles move with the same kinetic energy
(D) The particles have fallen through the same height

11. The threshold wavelength for photoelectric emission from a material is 5200 Å. This material when illuminated with .... monochromatic radiation emits photoelectrons.
(A) 1 W UV (B) 50 W UV
(C) 1 W IR (D) 50 W IR

12. Figure shows the results of an experiment involving photoelectric effect. The graphs A, B, C, D related the light beam having different wavelengths.



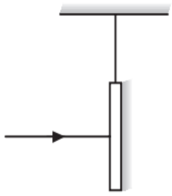
(A) Beam B has highest frequency
(B) Beam C has longest wavelength
(C) Beam A has the highest rate of photoelectric emission
(D) Photoelectrons ejected by beam B have the highest momentum

13. Light rays are incident on a metallic sheet. Then,
(A) the force exerted is independent of frequency of light incident
(B) the force depends on the direction of light incident
(C) the pressure is independent of frequency of light incident
(D) the pressure is proportional to the area of the plate

14. The momentum of a single photon of red light of frequency 400×10^{12} Hz moving through free space is

(A) zero (B) 8.8×10^{-28} kgms^{-2}
(C) 1.65×10^{-6} MeV/c (D) Data Insufficient

15. A small mirror is suspended by a thread as shown in figure. A short pulse of monochromatic light rays is incident normally on the mirror and gets reflected. Which of the following statements is/are correct?



(A) Mirror will start to oscillate.
(B) Wavelength of reflected rays will be greater than that of incident rays.
(C) Wavelength of reflected rays may be less than that of incident rays
(D) None of these

16. For a 75 W point light source assuming all the electric power consumed goes into emitted light of wavelength 600 nm, then
(A) frequency of the emitted light is 5×10^{14} Hz
(B) number of photons emitted per second is 2.3×10^{20}
(C) this emitted light on falling on a metal surface of work function 1.07 eV, will emit photoelectrons having kinetic energy between 0 and 1 eV
(D) on doubling the distance of this metal surface from the point source maximum kinetic energy of photoelectrons emitted becomes 0.25 eV

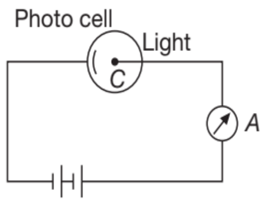
17. In an experiment for photoelectric effect, the frequency and intensity of a light source are both doubled, then
(A) The saturation photocurrent remains almost the same
(B) The saturation photocurrent becomes doubled
(C) The maximum kinetic energy of the photoelectrons is doubled
(D) The stopping potential becomes more than double

18. If the wavelength of light in an experiment on photoelectric effect is doubled,
(A) the photoelectric emission will not take place
(B) the photoelectric emission may or may not take place
(C) the stopping potential will increase
(D) the stopping potential will decrease

19. A metallic surface ejects electrons when exposed to green light of intensity I but no photoelectrons are emitted when exposed to yellow light of intensity I. It is possible to eject electrons from the same surface by
(A) yellow light of some intensity which is more than I.
(B) green light of any intensity.
(C) red light of any intensity.
(D) violet light of any intensity.

20. In an experiment of photoelectric effect, light from a point source of monochromatic light of wavelength 3000 Å is incident on a metal surface. The kinetic energies of photoelectrons range from zero to 4×10^{-19} J, then
(A) stopping potential for this light is 2.5 V
(B) threshold wavelength for the material is 7590 Å
(C) stopping potential will be doubled on reducing the distance and the wavelength of light source to half
(D) saturation current will be doubled on reducing the distance of source to half

21. Figure shows a photo cell being illuminated by a monochromatic light. If the intensity is kept constant and the frequency of the incident light is increased, then the



(A) photo electric current in the circuit decreases
(B) photo electric current in the circuit increases
(C) photo electric current in the circuit can be reduced to zero, when the polarity of the terminals is reversed.
(D) maximum kinetic energy of the photo electrons increases

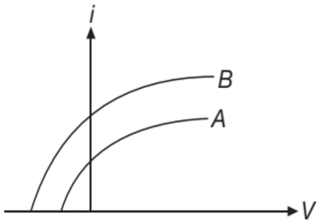
22. Light of wavelength 496 nm is incident on a metal surface causing ejection of photoelectrons for which stopping potential is 1.5 V, then
(A) the work function of the surface is 1 eV
(B) de-Broglie wavelength of fastest photoelectron is 100 nm
(C) to move the fastest electron in a circle of radius 1 m, perpendicular magnetic field B required is $4\ \mu$T
(D) this fastest electron when strikes zinc target can produce X-rays

23. Which of the following statements about photoelectric effect is/are false?
(A) It exhibits the particle nature of radiation
(B) Electrons are emitted only if the radiation has a frequency above a certain value

(C) All the electrons emitted by radiation of a particular frequency have the same energy
(D) Changing the intensity of radiation changes the maximum energy with which the electrons can be emitted

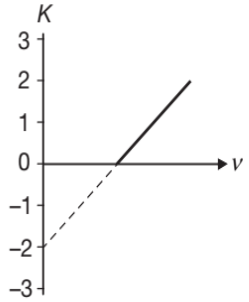
24. Radiations of monochromatic waves of wavelength 400 nm are made incident on the surface of metals Zn, Fe and Ni of work functions 3.4 eV, 4.8 eV and 5.9 eV respectively $(\text{take } hc = 12400\text{ eVÅ})$
(A) maximum KE associated with photoelectrons from the surface of any metal is 0.3 eV
(B) no photoelectrons are emitted from the surface of *Ni*
(C) if the wavelength of source of radiation is doubled then KE of photoelectrons is also doubled
(D) photoelectrons will be emitted from the surface of all the three metals if the wavelength of incident radiations is less than 200 nm

25. Observe the current vs voltage graphs of two photocells A and B receiving same intensity of a monochromatic beam. You may consider the plate area receiving the light to be same. Select the correct statement (s).



(A) Photoelectric efficiency of cell B must be greater than cell A.
(B) Photoelectric efficiency of cell B may be greater than cell A.
(C) Work function for cell B must be greater than that of cell A.
(D) Work function for cell B must be less than that of cell A.

26. Figure represents a graph of kinetic energy (K) of photoelectrons (in eV) and frequency (ν) for a metal used as cathode in photoelectric experiment. The work function of metal is



(A) 1 eV (B) 1.5 eV
(C) 2 eV (D) 3 eV

27. In PROBLEM 26, the threshold frequency is nearly
(A) 5×10^{14} Hz (B) 10×10^{14} Hz
(C) 2.5×10^{14} Hz (D) cannot be estimated

28. Which of the following statements are incorrect?
(A) Saturation current is photo electric effect experiment is independent of frequency of light incident.
(B) Stopping potential increases with increase in intensity of light incident.
(C) Stopping potential increases with decrease in wavelength of light incident.
(D) Photo electric effect depends on the work function of the metal.

29. It is necessary to consider light as a stream of photons to explain
(A) Photoelectric effect
(B) Compton effect
(C) Polarization of light
(D) Diffraction of light

REASONING BASED QUESTIONS

This section contains Reasoning type questions, each having four choices (A), (B), (C) and (D) out of which ONLY ONE is correct. Each question contains STATEMENT 1 and STATEMENT 2. You have to mark your answer as

Bubble (A) If both statements are TRUE and STATEMENT 2 is the correct explanation of STATEMENT 1.
Bubble (B) If both statements are TRUE but STATEMENT 2 is not the correct explanation of STATEMENT 1.
Bubble (C) If STATEMENT 1 is TRUE and STATEMENT 2 is FALSE.
Bubble (D) If STATEMENT 1 is FALSE but STATEMENT 2 is TRUE.

1. **Statement-1:** Threshold wavelength of certain metal is λ_0. Light of wavelength slightly less than λ_0 is incident on the plate. It is found that after some time the emission of electrons stops.

Statement-2: The ejected electrons experience force of attraction due to development of positive charges on plate which after certain time is adequate enough to hold them to plate itself.

2. **Statement-1:** A photon has no rest mass, yet it carries definite momentum.
Statement-2: Momentum of photon is due to its energy and hence its equivalent mass.

3. **Statement-1:** In a photoelectric effect, the current increases when positive potential of collector is increased, before saturation of current.
Statement-2: The number of emitted photoelectrons increases.

4. **Statement-1:** The de Broglie wavelength of an electron accelerated through 941 volt is 0.4 Å.
Statement-2: Higher the accelerating potential, smaller is the de-Broglie wavelength.

5. **Statement-1:** Work function of copper is greater than that of sodium. But both will have same value of the threshold frequency and threshold wavelength.
Statement-2: The frequency is inversely proportional to wavelength.

6. **Statement-1:** In case of an electron and a photon having same momentum, wavelength associated with electron is smaller.
Statement-2: Electron cannot move with a speed of photon.

7. **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.

8. **Statement-1:** A proton, a deutron and an α-particle are accelerated by the same potential difference. Their velocities will be in the ratio of $1:1:\sqrt{2}$.
Statement-2: Kinetic energy, $E = qV = \frac{1}{2}mv^2$

9. **Statement-1:** Photoelectric effect demonstrates the wave nature of light.
Statement-2: The number of photoelectrons is proportional to the frequency of light.

10. **Statement-1:** A photon has no rest mass, yet it carries momentum.
Statement-2: Momentum depends more on velocity than that of mass.

11. **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.

12. **Statement-1:** Effective mass of photon varies with wavelength.
Statement-2: $E = mc^2$ is the relation between mass and energy.

13. **Statement-1:** Though 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 metal surface may be lost in collision with other atoms in the metal before the electron is ejected out of metal.

14. **Statement-1:** A photon and an electron, both of energy 1 MeV has same wavelength.
Statement-2: $E = 22m_ec^2 = 10^6\text{ eV}$

15. **Statement-1:** The velocity of body of rest mass m_0 is $\frac{\sqrt{3}}{2}c$ (where c is the velocity of light in vacuum) then mass of the body is $2m_0$.
Statement-2: Moving mass is given as $m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$

16. **Statement-1:** In the process of photoelectric emission by monochromatic light, all the emitted photoelectrons possess the same kinetic energy.
Statement-2: In photoelectric effect a single photon interacts with a single electron and electron is emitted only if energy of each of incident photon is greater than the work function.

17. **Statement-1:** de-Broglie wavelength of an electron accelerated through a potential difference of V volt is $\lambda = \frac{12.72}{\sqrt{V}}$ Å.
Statement-2: de-Brogle wavelength of an electron is given by $\lambda = \frac{h}{mv}$

LINKED COMPREHENSION TYPE QUESTIONS

This section contains Linked Comprehension Type Questions or Paragraph based Questions. Each set consists of a Paragraph followed by questions. Each question has four choices (A), (B), (C) and (D), out of which only one is correct. (For the sake of competitiveness there may be a few questions that may have more than one correct options)

Comprehension 1

A photocell is operating in saturation mode with a photo current $20\ \mu A$ when a monochromatic radiation of wave length $3000\ Å$ and power $1\ MW$ is incident. When another monochromatic radiation of wave length $1500\ Å$ and power $5\ MW$ is incident, it is observed that the maximum velocity of photo electron is doubled. Assuming efficiency of photoelectron generation per incident photon to be same for both the cases. Based on above information, answer the following questions.

1. The threshold wavelength for the cell is
(A) $3500\ Å$ (B) $4000\ Å$
(C) $4500\ Å$ (D) $5000\ Å$

2. The saturation current in second case is
(A) $50\ \mu A$ (B) $40\ \mu A$
(C) $60\ \mu A$ (D) $45\ \mu A$

3. The efficiency of photoelectron generation per incident photon is
(A) 8.5% (B) 8.25%
(C) 8% (D) 8.75%

Comprehension 2

The radiations emitted when an electron jumps from $n = 3$ to $n = 2$ orbit of hydrogen atom falls on a metal to produce photoelectrons. The electrons emitted from the metal surface with maximum kinetic energy are made to move perpendicular to a magnetic field of strength $\frac{1}{320}$ T in a radius of 10^{-3} m. Based on above information, answer the following questions.

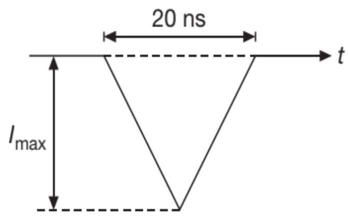
4. The kinetic energy of the electrons is
(A) 0.56 eV (B) 1.32 eV
(C) 0.86 eV (D) 1.76 eV

5. The work function of the metal is
(A) 1.89 eV (B) 1.03 eV
(C) 1.58 eV (D) 2.32 eV

6. Wavelength of radiation is nearly
(A) $6565\ Å$ (B) $5555\ Å$
(C) $4545\ Å$ (D) $3535\ Å$

Comprehension 3

A photomultiplier tube is to be used to detect light pulses each of which consists of a small but fixed number of photons. The average photoelectric efficiency (i.e. a photon's chance of causing the emission of a detectable photoelectron) is 10%. Assuming that the photomultiplier gain is 10^6 and that the output current as a function of time can be approximated as shown in figure.



Based on the information provided, answer the following questions.

7. I_{max} when averaged over many pulses is $80\ \mu A$
(A) The charge carried by one pulse is 9×10^{-13} C
(B) Number of photoelectrons emitted per light pulse is 10
(C) Number of photons in one light pulse is 50
(D) Number of electrons carried by one pulse is 5×10^5

8. The probability that all the photons of a light pulse will go undetected is (N is the number of photons in one light pulse)
(A) $\left(\frac{90}{100}\right)^{\frac{N}{10}}$ (B) $\left(\frac{90}{100}\right)^{\frac{N}{50}}$
(C) $(0.9)^{50}$ (D) $(0.9)^5$

9. The fluctuation in the value of I_{max} will be small if
(A) number of photons in the pulse is increased
(B) number of electrons in pulse is decreased
(C) number of photons in the pulse is decreased
(D) total quantity of charge carried by pulse is decreased

Comprehension 4

de-Broglie suggested that every moving particle has a wavelength associated with it, which is given by $\lambda = \frac{h}{p}$ or $\lambda = \frac{h}{\sqrt{2mK}}$. With the help of these formulae we know that wavelength for a charged particle accelerated through a potential V is $\lambda = \frac{h}{\sqrt{2mqV}}$. Based on above information, answer the following questions.

10. Proton and alpha particle are accelerated through same potential difference. Then ratio of their wavelength is
(A) $1:\sqrt{2}$ (B) $2\sqrt{2}:1$
(C) $2:1$ (D) $1:2\sqrt{2}$

11. When an electron is accelerated through 150 V potential difference, then the wavelength associated with it is approximately

(A) 1 Å (B) 2 Å
(C) 3 Å (D) 4 Å

12. If electron and alpha particle have same momentum the ratio of their wavelength is

(A) 1840 : 1 (B) 1 : 1840
(C) 1 : 1 (D) None of these

Comprehension 5

Light of wavelength 3100 Å is falling on four elements *A*, *B*, *C* and *D* having work function ϕ_0 given by 2.5 eV, 3.5 eV, 4.5 eV and 5.5 eV respectively. Given that $hc = 12400$ eVÅ. Based on the information provided, answer the following questions.

13. Photo-electrons are emitted from following elements

(A) *A* (B) *A* and *B*
(C) *A*, *B* and *C* (D) *A*, *B*, *C* and *D*

14. Maximum wavelength of light, which can electrons from all four elements is

(A) 4960 Å (B) 3540 Å
(C) 2750 Å (D) 2250 Å

Comprehension 6

A large number of identical balls each having a mass of 66.3 g are thrown with speed of 5 ms^{-1} into a house through two tall, narrow, parallel windows spaced 0.6 m apart, the choice of window as target being random at each throw. Fringes are formed on a wall 12 m behind the windows. Assuming the Plank's constant to have a hypothetical value of $h = 6.63 \times 10^{-3}$ Js. Based on above information, answer the following questions.

15. de-Broglie wavelength of the balls is

(A) 0.2 m (B) 0.02 m
(C) 2 m (D) 20 m

16. Fringe width obtained on the wall is

(A) 0.01 m (B) 0.2 m
(C) 0.5 m (D) 0.4 m

17. If electrons are used in place of balls, moving with speed 10^7 ms^{-1} in the experiment then

(A) Fringe width will decrease
(B) No interference pattern is obtained
(C) Fringe width will not increase
(D) Interference pattern is obtained but it is not possible to observe it

Comprehension 7

A laser delivers 10 kJ of 1 micron wavelength radiation in 10^{-9} seconds onto a focal spot of 10^{-3} cm^2 area. All the energy was absorbed and converted into thermal energy uniformly distributed over a sphere whose size just matches that of the focal spot containing 5×10^{18} hydrogen atoms (fully ionized). Based on the information provided, answer the following questions.

18. The peak electric field is

(A) 2.75×10^{11} Vm^{-1} (B) 5.25×10^{11} Vm^{-1}
(C) 8.5×10^{11} Vm^{-1} (D) 10×10^{11} Vm^{-1}

19. Radiation pressure is approximately

(A) 330 Giga Pascal (B) 400 Giga Pascal
(C) 500 Giga Pascal (D) 860 Giga Pascal

20. The pressure of this material is

(A) 280 Tera Pascal
(B) 480 Tera Pascal
(C) 560 Tera Pascal
(D) 720 Tera Pascal

Comprehension 8

A surface has light of wavelength $\lambda = 496$ nm incident on it, causing the ejection of photoelectrons for which the stopping potential is found to be 1.5 V. Based on above information, answer the following questions.

21. The de-Broglie wavelength of the fastest photoelectron emitted is

(A) 75 nm (B) 100 nm
(C) 135 nm (D) 235 nm

22. To move the fastest electron in a circle of radius 1 m, the value of perpendicular magnetic field *B* is

(A) 4.1×10^{-6} T (B) 2.1×10^{-5} T
(C) 3.2×10^{-5} T (D) 5.2×10^{-6} T

23. The threshold wavelength for photoelectric emission to occur is nearly

(A) 1250 nm (B) 2000 nm
(C) 2250 nm (D) 3000 nm

Comprehension 9

Light beam of energy 2.5 eV incident on metal surface having work function of 2 eV. Taking $hc = 12400$ eVÅ, and on the information provided, answer the following questions.

24. Wavelength of incident photon is

(A) 5000 Å (B) 6000 Å
(C) 7000 Å (D) 8000 Å

25. de-Broglie wavelength of photo electron is

(A) 17.5 nm (B) 1.75 nm
(C) 35 nm (D) 3.5 nm

Comprehension 10

A parallel beam of monochromatic light $(\lambda = 663 \text{ nm})$ of intensity 30 kWm^{-2} is incident normally on a 100 mm^2 completely absorbing screen for 10 s. Based on above information, answer the following questions.

26. Pressure exerted by beam on the surface is

(A) 10^{-5} Pa (B) 10^{-4} Pa
(C) 2×10^{-4} Pa (D) 5×10^{-5} Pa

27. Momentum transferred to the screen during the interval is

(A) 10^{-8} kgms^{-1} (B) 5×10^{-8} kgms^{-1}
(C) 10^{-7} kgms^{-1} (D) 2×10^{-7} kgms^{-1}

28. Number of photons striking the screen during the interval is

(A) 5×10^{19} (B) 10^{20}
(C) 2×10^{20} (D) 5×10^{20}

Comprehension 11

A metallic surface, when illuminated by light of frequency 8×10^{14} Hz and 12×10^{14} Hz emits photoelectrons of maximum kinetic energy 0.5 eV and 2.0 eV. Based on the information provided answer the following questions.

29. The value of Planck's constant is

(A) 6.0×10^{-34} Js (B) 6.2×10^{-34} Js
(C) 6.4×10^{-34} Js (D) 6.6×10^{-34} Js

30. The work function of metal is

(A) 0.5 eV (B) 1.5 eV
(C) 2.5 eV (D) 3.5 eV

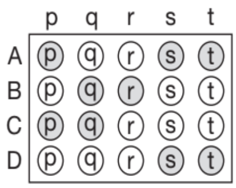
31. de-Broglie wavelength of electron when its energy is 0.5 eV

(A) 8.68 Å (B) 17.35 Å
(C) 21.25 Å (D) 24.54 Å

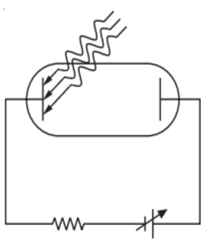
MATRIX MATCH/COLUMN MATCH TYPE QUESTIONS

Each question in this section contains statements given in two columns, which have to be matched. The statements in **COLUMN-I** are labelled A, B, C and D, while the statements in **COLUMN-II** are labelled p, q, r, s (and t). Any given statement in **COLUMN-I** can have correct matching with **ONE OR MORE** statement(s) in **COLUMN-II**. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following examples:

If the correct matches are A → (p, s, t); B → (q, r); C → (p, q); and D → (s, t); then the correct darkening of bubbles will look like the following:



1. In the shown experimental setup to study photoelectric effect, two conducting electrodes are enclosed in an evacuated glass-tube as shown.



A parallel beam of monochromatic light, falls on photosensitive electrodes. The emf of battery shown is high enough such that all photo electrons ejected from left electrode will reach the right electrode. Under initial conditions photoelectrons are emitted. As changes are made in each situation of **COLUMN-I**, match the statements in **COLUMN-I** with results in **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) If frequency of incident light is increased keeping its intensity constant	(p) magnitude of stopping potential will increase
(B) If frequency of incident light is increased an it's intensity is decreased	(q) current through circuit may stop

(Continued)

COLUMN-I	COLUMN-II
(C) If work function of photo-sensitive electrode is increased	(r) maximum kinetic energy of ejected photo electron will increase
(D) If intensity of incident light is increased keeping it's frequency constant.	(s) Saturation current will increase

2. In a photoelectric effect experiment, if f is the frequency of radiations incident on the metal surface and I is the intensity of incident radiations, then match the quantities in **COLUMN-I** with their matches in **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) If distance between cathode and anode is increased.	(p) Stopping potential increases.
(B) If I is increased keeping f and work function constant.	(q) Saturation current increases.
(C) Work function is decreased keeping f and I constant.	(r) Maximum kinetic energy of photo electron increases.
(D) If f is increased keeping I and work function constant.	(s) Stopping potential remain same.

3. In a photoelectric effect experiment, if the following changes are made, then match the **COLUMN-I** with **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) If intensity of incident light is increased keeping its frequency constant.	(p) Stopping potential will increase.
(B) If work function of photo sensitive electrode is increased.	(q) Current through circuit may stop.

(Continued)

COLUMN-I	COLUMN-II
(C) If frequency of incident light is increased and its intensity is decreased.	(r) Maximum kinetic energy of ejected photoelectrons will increase.
(D) If frequency of incident light is increased keeping its intensity constant.	(s) Saturation current will increase.

4. Match the properties in **COLUMN-I** with their respective phenomenon in **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) Photon character of radiation.	(p) Photoelectric effect.
(B) Wave character of radiation.	(q) Compton effect.
(C) Interaction of a photon with an electron, such that photon energy is much greater than the binding energy of electron, is more likely to result in.	(r) Diffraction.
(D) Interaction of a photon with an electron, such that photon energy is equal to or slightly greater than the binding energy of electron, is more likely to result in.	(s) Interference.

5. Match the experiments in **COLUMN-I** with their respective conclusions in **COLUMN-II**

COLUMN-I	COLUMN-II
(A) Photoelectric effect	(p) Wave nature of light
(B) Millikan's experiment	(q) Particle nature of light
(C) Young's Double slit experiment	(r) Particle nature of electron
(D) Davisson-Germer experiment	(s) Wave nature of electron

6. Match the wavelengths in **COLUMN-I** to the respective matches in **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) 0.1 Å	(p) de-Broglie wavelength of electron in *X*-ray tube.
(B) 1 Å	(q) Photoelectric threshold wavelength.
(C) 10 Å	(r) *X*-ray wavelength.
(D) 5000 Å	(s) de-Broglie wavelength of most energetic photoelectron emitted from metal surface in photoelectric effect.

7. Some quantities related to photoelectric effect are mentioned under **COLUMN-I** and **COLUMN-II**. Match each quantity on **COLUMN-I** with the corresponding quantity in **COLUMN-II** on which it depends.

COLUMN-I	COLUMN-II
(A) de-Broglie wavelength of photoelectron.	(p) Frequency of light.
(B) Force due to radiation falling on metal plate.	(q) Work function.
(C) Stopping potential.	(r) Area of photo sensitive plate.
(D) Saturation current.	(s) Intensity of light (at constant ν).

8. In a photoelectric effect experiment, if f is the frequency of radiations incident on the metal surface and I is the intensity of incident radiations, then match the following.

COLUMN-I	COLUMN-II
(A) Work function is decreased keeping f and I constant.	(p) Stopping potential increases.
(B) If I is increased keeping f and work function constant.	(q) Saturation current increases.
(C) If distance between cathode and anode is increased.	(r) Maximum kinetic energy of photoelectron increases.
(D) If f is increased keeping I and work function constant.	(s) Stopping potential remain same.

9. In the experimental setup for a photocell, the wavelength of the light incident on the cathode is initially 0.6 times the threshold wavelength for the material of the cathode. Certain changes in the experiment setup are given in **COLUMN-I** and their possible effects are given in **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) The intensity of the incident light is doubled but the frequency remains unaltered	(p) Saturation photocurrent remains the same
(B) Both the intensity and wavelength of the incident light are doubled	(q) Photocurrent falls to zero
(C) The intensity of the incident light is doubled and its wavelength is made half	(r) Stopping potential increases
(D) The intensity of the incident light remains the same and the wavelength is made half	(s) Saturation photocurrent increases

10. With respect to photoelectric effect experiment, match the entries of **COLUMN-I** with the entries of **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) If I is increased keeping f and ϕ constant.	(p) Stopping potential increases.
(B) If f (frequency) is increased keeping I (intensity) and ϕ (work function) constant.	(q) Saturation photocurrent increases.

(Continued)

COLUMN-I	COLUMN-II
(C) If ϕ is decreased keeping f and I constant.	(r) Maximum K.E. of the photoelectrons increases.
(D) If the distance between anode and cathode increases.	(s) Stopping potential remains the same.

11. If radiation of energy E, intensity I falls on different kinds of surfaces mentioned, then match the quantities in **COLUMN-I** with their respective answers in **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) Radiation pressure for a perfectly absorbing surface.	(p) $(1+\rho)\frac{I}{c}$
(B) Radiation pressure for a perfectly reflecting surface.	(q) $\frac{2E}{c}$
(C) Radiation pressure for a surface of reflection coefficient (ρ).	(r) $\frac{I}{c}$
(D) Impulse on a perfectly absorbing surface.	(s) $\frac{2I}{c}$
(E) Impulse on a perfectly reflecting surface.	(t) $(1+\rho)\frac{E}{c}$
(F) Impulse on a surface of reflection coefficient (ρ).	(u) $\frac{E}{c}$

INTEGER/NUMERICAL ANSWER TYPE QUESTIONS

In this section, the answer to each question is a numerical value obtained after doing series of calculations based on the data given in the question(s).

1. The human eye can barely detect a yellow light (6000 Å) that delivers 1.7×10^{-8} W to the retina. How many photons strike the retina in one second is $\alpha\times10^{\beta}$, where α is measures to the nearest integer and β is the integer. Calculate $\frac{\beta}{\alpha}$.

2. A metal plate is placed 5 metre from a monochromatic light source whose power output is 10^{-3} W. Consider that a given ejected photoelectrons may collect its energy from a circular area of the plate as large as ten atomic diameters (10^{-9} m) in radius. The energy required to remove an electron through the metal surface is about 5 eV. Assuming light to be a wave, how long, in hour, would it take for such a 'target' to soak up this much energy from such a light source.

3. Energy from the sun is received on the earth at the rate of $2\text{ cal cm}^{-2}\text{ min}^{-1}$. If average wavelength of solar light be taken as 6600 Å, then $x\times10^{18}$ photons are received on earth per cm^2 per minute, find x.

   Take $1\text{ cal}=4.2\text{ J}$, $c=3\times10^8\text{ ms}^{-1}$.

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

5. Light of wavelength 180 nm ejects photoelectrons from a plate of metal whose work-function is 2 eV. If a uniform magnetic field of 5×10^{-5} T be applied parallel to the plate, what would be radius of the path, in mm, followed by electrons ejected normally from the plate with maximum energy.

6. A metallic sphere of radius 10 cm is kept in the path of a parallel beam of light of intensity 10^{-2} Wm^{-2}. Calculate the approximate force to the closest integer (in piconewton) exerted by the beam on the sphere.

7. The maximum kinetic energy of photoelectrons emitted from a certain metallic surface is 30 eV when monochromatic radiation of wavelength λ falls on it. When the same surface is illuminated with light of wavelength 2λ, the maximum, kinetic energy of photoelectrons is observed to be 10 eV. Calculate the wavelength λ and determine the maximum wavelength of incident radiation (both in Å) for which photoelectrons can be emitted by this surface. Given $h=4\times10^{-15}$ eVs and $c=3\times10^8\text{ ms}^{-1}$.

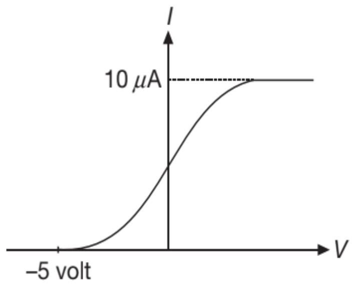
8. On a certain metal light of frequency $\nu=5\nu_0$ falls then maximum velocity of electrons emitted is $8\times10^6\text{ ms}^{-1}$, where ν_0 is threshold frequency of metal. If $\nu=2\nu_0$ then the maximum velocity of photoelectron is $x\times10^6\text{ ms}^{-1}$. Find x.

9. When a surface 1 cm thick is illuminated with light of wavelength λ, the stopping potential is V_0. When the same surface is illuminated by light of wavelength 3λ, the stopping potential is $\frac{V_0}{6}$. If the threshold wavelength for metallic surface is $n\lambda$. Calculate n.

10. A metallic sphere of radius 21 cm is kept in the path of a parallel beam of light of intensity $\frac{1}{110}$ Wm^{-2}. The force exerted by beam on the sphere is $x \times 10^{-13}$ N. Find x.

11. The wavelength of light incident on a metal surface is reduced from 300 nm to 200 nm (both are less than threshold wavelength). Find the change in the stopping potential, in volt, for photoelectrons emitted from the surface. Take $h = 6.6 \times 10^{-34}$ Js.

12. In the photoelectric experiment, if we use a monochromatic light, the I–V curve is as shown. If work function of the metal is 2 eV, estimate the power of light used (in W). Assume efficiency of photo emission to be 10^{-3} %, i.e., number of photoelectrons emitted are 10^{-3} % of number of photons incident on metal.



13. If photons of ultraviolet light of energy 12 eV are incident on a metal surface of work function of 4 eV, then find the stopping potential (in V).

14. A point isotropic light source of power $P = 12$ watts is located on the axis of a circular mirror of radius $R = 3$ cm. If distance of source from the centre of mirror is $a = 39$ cm and reflection coefficient of mirror is $r = 0.70$, then the force exerted by light ray on the mirror is $x \times 10^{-y}$ N. Calculate $\frac{y}{x}$.

15. A proton and an α-particle are fired through the same magnetic fields which is perpendicular to their velocity vectors. Both move such that radius of curvature of their path is the same. Find the ratio of their de-Broglie wavelengths.

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1. **[Online April 2019]**
Two particles move at right angle to each other. Their de Broglie wavelengths are λ_1 and λ_2 respectively. The particles suffer perfectly inelastic collision. The de Broglie wavelength λ, of the final particle, is given by
(A) $\lambda = \sqrt{\lambda_1 \lambda_2}$
(B) $\lambda = \frac{\lambda_1 + \lambda_2}{2}$
(C) $\frac{2}{\lambda} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$
(D) $\frac{1}{\lambda^2} = \frac{1}{\lambda_1^2} + \frac{1}{\lambda_2^2}$

2. **[Online April 2019]**
A nucleus A, with a finite de-Broglie wavelength λ_A, undergoes spontaneous fission into two nuclei B and C of equal mass. B flies in the same direction as that of A, while C flies in the opposite direction with a velocity equal to half of that of B. The de-Broglie wavelength λ_B and λ_C of B and C are respectively
(A) $2\lambda_A$, λ_A
(B) λ_A, $\frac{\lambda_A}{2}$
(C) $\frac{\lambda_A}{2}$, λ_A
(D) λ_A, $2\lambda_A$

3. **[Online April 2019]**
The electric field of light wave is given as $\vec{E} = 10^{-3} \cos\left(\frac{2\pi x}{5 \times 10^{-7}} - 2\pi \times 6 \times 10^{14} t\right)\hat{x}\ \frac{\text{N}}{\text{C}}$. This light falls on a metal plate of work function 2 eV. The stopping potential of the photo-electrons is

Given, $E(\text{in eV}) = \frac{12374}{\lambda(\text{in Å})}$
(A) 0.48 V
(B) 2.48 V
(C) 0.72 V
(D) 2.0 V

4. **[Online April 2019]**
50 Wm^{-2} energy density of sunlight is normally incident on the surface of a solar panel. Some part of incident energy (25%) is reflected from the surface and the rest is absorbed. The force exerted on 1 m^2 surface area will be close to $(c = 3 \times 10^8\ \text{ms}^{-1})$
(A) 20×10^{-8} N
(B) 35×10^{-8} N
(C) 15×10^{-8} N
(D) 10×10^{-8} N

5. [Online April 2019]
A particle P is formed due to a completely inelastic collision of particles x and y having de-Broglie wavelengths λ_x and λ_y respectively. If x and y were moving in opposite directions, then the de-Broglie wavelength of P is

(A) $\dfrac{\lambda_x \lambda_y}{|\lambda_x - \lambda_y|}$ (B) $\lambda_x - \lambda_y$
(C) $\lambda_x + \lambda_y$ (D) $\dfrac{\lambda_x \lambda_y}{\lambda_x + \lambda_y}$

6. [Online April 2019]
In a photoelectric effect experiment the threshold wavelength of light is 380 nm. If the wavelength of incident light is 260 nm, the maximum kinetic energy of emitted electrons will be

Given $E(\text{in eV}) = \dfrac{1237}{\lambda(\text{in nm})}$

(A) 4.5 eV (B) 15.1 eV
(C) 3.0 eV (D) 1.5 eV

7. [Online April 2019]
A 2 mW laser operates at a wavelength of 500 nm. The number of photons that will be emitted per second is

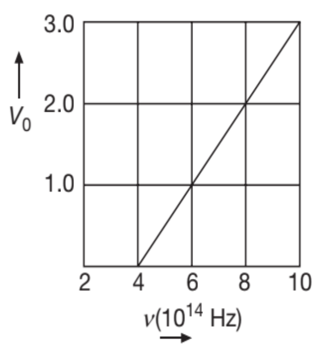
[Given Planck's constant $h = 6.6 \times 10^{-34}\text{ Js}$, speed of light $c = 3.0 \times 10^{8}\text{ ms}^{-1}$]

(A) 2×10^{16} (B) 1.5×10^{16}
(C) 1×10^{16} (D) 5×10^{15}

8. [Online April 2019]
Light is incident normally on a completely absorbing surface with an energy flux of 25 Wcm^{-2}. If the surface has an area of 25 cm^2, the momentum transferred to the surface in 40 min time duration will be

(A) $3.5 \times 10^{-6}\text{ Ns}$ (B) $6.3 \times 10^{-4}\text{ Ns}$
(C) $5.0 \times 10^{-3}\text{ Ns}$ (D) $1.4 \times 10^{-6}\text{ Ns}$

9. [Online April 2019]
The stopping potential V_0 (in volt) as a function of frequency (ν) for a sodium emitter, is shown in the figure. The work function of sodium, from the data plotted in the figure, will be
(Given: Planck's constant $(h) = 6.63 \times 10^{-34}\text{ Js}$, electron charge $e = 1.6 \times 10^{-19}\text{ C}$)



(A) 1.95 eV (B) 2.12 eV
(C) 1.82 eV (D) 1.66 eV

10. [Online April 2019]
Consider an electron in a hydrogen atom, revolving in its second excited state (having radius 4.65 Å). The de-Broglie wavelength of this electron is

(A) 3.5 Å (B) 12.9 Å
(C) 9.7 Å (D) 6.6 Å

11. [Online January 2019]
Surface of certain metal is first illuminated with light of wavelength $\lambda_1 = 350\text{ nm}$ and then, by light of wavelength $\lambda_2 = 540\text{ nm}$. It is found that the maximum speed of the photo electrons in the two cases differ by a factor of 2. The work function of the metal (in eV) is close to $\left(\text{Energy of photon} = \dfrac{1240}{\lambda(\text{in nm})}\text{ eV}\right)$

(A) 1.8 (B) 5.6
(C) 2.5 (D) 1.4

12. [Online January 2019]
The magnetic field associated with a light wave is given, at the origin, by

$B = B_0\left[\sin(3.14 \times 10^7)ct + \sin(6.28 \times 10^7)ct\right]$.

If this light falls on a silver plate having a work function of 4.7 eV, what will be the maximum kinetic energy of the photo electrons? $(c = 3 \times 10^8\text{ ms}^{-1}, h = 6.6 \times 10^{-34}\text{ Js})$

(A) 8.52 eV (B) 7.72 eV
(C) 12.5 eV (D) 6.82 eV

13. [Online January 2019]
In an electron microscope, the resolution that can be achieved is of the order of the wavelength of electrons used. To resolve a width of $7.5 \times 10^{-12}\text{ m}$, the minimum electron energy required is close to

(A) 100 keV (B) 1 keV
(C) 500 keV (D) 25 keV

14. [Online January 2019]
A metal plate of area $1 \times 10^{-4}\text{ m}^2$ is illuminated by a radiation of intensity 16 mWm^{-2}. The work function of the metal is 5 eV. The energy of the incident photons is 10 eV and only 10% of it produces photo electrons. The number of emitted photo electrons per second and their maximum energy, respectively, will be $\left[1\text{ eV} = 1.6 \times 10^{-19}\text{ J}\right]$

(A) 10^{14} and 10 eV (B) 10^{11} and 5 eV
(C) 10^{10} and 5 eV (D) 10^{12} and 5 eV

15. [Online January 2019]
If the de-Broglie wavelength of an electron is equal to 10^{-3} times the wavelength of a photon of frequency 6×10^{14} Hz, then the speed of electron is equal to

(Speed of light $=3\times10^{8}\ \text{ms}^{-1}$
Planck's constant $=6.63\times10^{-34}$ Js
Mass of electron $=9.1\times10^{-31}$ kg)

(A) $1.7\times10^{6}\ \text{ms}^{-1}$ (B) $1.45\times10^{6}\ \text{ms}^{-1}$
(C) $1.8\times10^{6}\ \text{ms}^{-1}$ (D) $1.1\times10^{6}\ \text{ms}^{-1}$

16. [Online January 2019]
In a photoelectric experiment, the wavelength of the light incident on a metal is changed from 300 nm to 400 nm. The decrease in the stopping potential is close to $\left(\frac{hc}{e}=1240\ \text{nmV}\right)$

(A) 1.0 V (B) 2.0 V
(C) 1.5 V (D) 0.5 V

17. [Online January 2019]
A particle A of mass m and charge q is accelerated by a potential difference of 50 V. Another particle B of mass 4 m and charge q is accelerated by a potential difference of 2500 V. The ratio of de-Broglie wavelengths $\frac{\lambda_A}{\lambda_B}$ is close to

(A) 0.07 (B) 14.14
(C) 4.47 (D) 10.00

18. [Online January 2019]
When a certain photosensitive surface is illuminated with monochromatic light of frequency ν, the stopping potential for the photo current is $-\frac{V_0}{2}$. When the surface is illuminated by monochromatic light of frequency $\frac{\nu}{2}$, the stopping potential is $-V_0$. The threshold frequency for photoelectric emission is

(A) $\frac{3\nu}{2}$ (B) $\frac{4}{3}\nu$
(C) $\frac{5\nu}{3}$ (D) 2ν

19. [Online January 2019]
In a Frank-Hertz experiment, an electron of energy 5.6 eV passes through mercury vapour and emerges with an energy 0.7 eV. The minimum wavelength of photons emitted by mercury atoms is close to

(A) 1700 nm (B) 2020 nm
(C) 250 nm (D) 220 nm

20. [Online 2018]
Two electrons are moving with non-relativistic speeds perpendicular to each other. If corresponding de Broglie wavelengths are λ_1 and λ_2, their de Broglie wavelength in the frame of reference attached to their centre of mass is

(A) $\lambda_{CM}=\frac{2\lambda_1\lambda_2}{\sqrt{\lambda_1^2+\lambda_2^2}}$ (B) $\lambda_{CM}=\lambda_1=\lambda_2$

(C) $\lambda_{CM}=\left(\frac{\lambda_1+\lambda_2}{2}\right)$ (D) $\frac{1}{\lambda_{CM}}=\frac{1}{\lambda_1}+\frac{1}{\lambda_2}$

21. [Online 2018]
If the de Broglie wavelength associated with a proton and an α-particle are equal, then the ratio of velocities of the proton and the α-particle will be

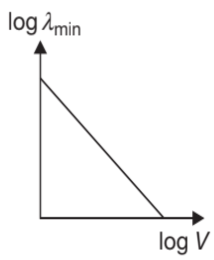
(A) $1:2$ (B) $2:1$
(C) $1:4$ (D) $4:1$

22. [Online 2018]
The de-Broglie wavelength (λ_B) associated with the electron orbiting in the second excited state of hydrogen atom is related to that in the ground state (λ_G) by

(A) $\lambda_B=\frac{\lambda_G}{3}$ (B) $\lambda_B=3\lambda_G$

(C) $\lambda_B=\frac{\lambda_G}{2}$ (D) $\lambda_B=2\lambda_G$

23. [2017]
An electron beam is accelerated by a potential difference V to hit a metallic target to produce X-rays. It produces continuous as well as characteristic X-rays. If $\lambda_{\min}$ is the smallest possible wavelength of X-ray in the spectrum, the variation of $\log\lambda_{\min}$ with $\log V$ is correctly represented in

(A)


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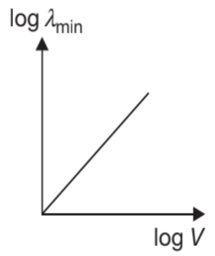

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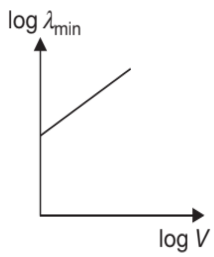
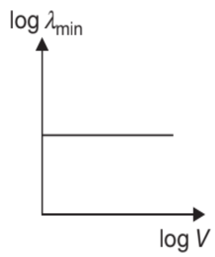


(D)


24. **[2017]**
A particle A of mass m and initial velocity v collides with a particle B of mass $\frac{m}{2}$ which is at rest. The collision is head on and elastic. The ratio of the de-Broglie wavelengths λ_A to λ_B after the collision is

(A) $\frac{\lambda_A}{\lambda_B}=\frac{1}{3}$ (B) $\frac{\lambda_A}{\lambda_B}=2$
(C) $\frac{\lambda_A}{\lambda_B}=\frac{2}{3}$ (D) $\frac{\lambda_A}{\lambda_B}=\frac{1}{2}$

25. **[Online 2017]**
The maximum velocity of the photoelectrons emitted from the surface is v when light of frequency n falls on a metal surface. If the incident frequency is increased to $3n$, the maximum velocity of the ejected photoelectrons will be

(A) more than $\sqrt{3}v$ (B) less than $\sqrt{3}v$
(C) v (D) equal to $\sqrt{3}v$

26. **[Online 2017]**
A Laser light of wavelength 660 nm is used to weld Retina detachment. If a Laser pulse of width 60 ms and power 0.5 kW is used, the approximate number of photons in the pulse are
[Take Planck's constant $h=6.62\times10^{-34}$ Js]

(A) 10^{19} (B) 10^{22}
(C) 10^{18} (D) 10^{20}

27. **[2016]**
Radiation of wavelength λ, is incident on a photocell. The fastest emitted electron has speed v. If the wavelength of changed to $\frac{3\lambda}{4}$, the speed of the fastest emitted electron will be

(A) $=v\left(\frac{3}{5}\right)^{\frac{1}{2}}$ (B) $>v\left(\frac{4}{3}\right)^{\frac{1}{2}}$
(C) $<v\left(\frac{4}{3}\right)^{\frac{1}{2}}$ (D) $=v\left(\frac{4}{3}\right)^{\frac{1}{2}}$

28. **[Online 2016]**
When photons of wavelength λ_1 are incident on an isolated sphere, the corresponding stopping potential is found to be V. When photons of wavelength λ_2 are used, the corresponding stopping potential was thrice that of the above value. If light of wavelength λ_3 is used then find the stopping potential for this case

(A) $\frac{hc}{e}\left(\frac{1}{\lambda_3}+\frac{1}{\lambda_2}-\frac{1}{\lambda_1}\right)$ (B) $\frac{hc}{e}\left(\frac{1}{\lambda_3}+\frac{1}{2\lambda_2}-\frac{1}{\lambda_1}\right)$
(C) $\frac{hc}{e}\left(\frac{1}{\lambda_3}-\frac{1}{\lambda_2}-\frac{1}{\lambda_1}\right)$ (D) $\frac{hc}{e}\left(\frac{1}{\lambda_3}+\frac{1}{2\lambda_2}-\frac{3}{2\lambda_1}\right)$

29. **[Online 2016]**
A photoelectric surface is illuminated successively by monochromatic light of wavelength λ and $\frac{\lambda}{2}$. If the maximum kinetic energy of the emitted photoelectrons in the second case is 3 times that in the first case, the work function of the surface is

(A) $\frac{hc}{2\lambda}$ (B) $\frac{hc}{\lambda}$
(C) $\frac{hc}{3\lambda}$ (D) $\frac{3hc}{\lambda}$

30. **[2015]**
Match **List-I** (Fundamental Experiment) with **List-II** (its conclusion) and select the correct option from the choices given below the list.

Column-I	Column-II
P. Franck-Hertz Experiment	(i) Particle nature of light
Q. Photo-electric Experiment	(ii) Discrete energy levels of atom
R. Davisson-Germer Experiment of electron	(iii) Wave nature
	(iv) Structure of atom

(A) P – (ii), Q – (i), R – (iii)
(B) P – (iv), Q – (iii), R – (ii)
(C) P – (i), Q – (iv), R – (iii)
(D) P – (ii), Q – (iv), R – (iii)

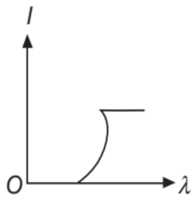
31. **[Online 2015]**
de-Broglie wavelength of an electron accelerated by a voltage of 50 V is close to ($|e|=1.6\times10^{-19}$ C, $m_e=9.1\times10^{-31}$ kg, $h=6.6\times10^{-34}$ Js)

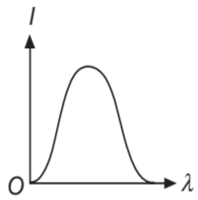
(A) 0.5 Å (B) 1.2 Å
(C) 1.7 Å (D) 2.4 Å

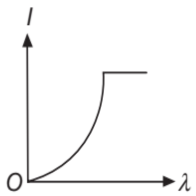
32. **[Online 2015]**
The de-Broglie wavelength associated with the electron in the $n=4$ level is

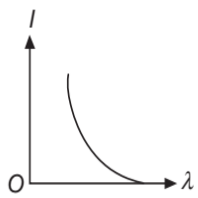
(A) two times the de-Broglie wavelength of the electron in the ground state
(B) four times the de-Broglie wavelength of the electron in the ground state
(C) half of the de-Broglie wavelength of the electron in the ground state
(D) $\frac{1}{4}$th of the de-Broglie wavelength of the electron in the ground state.

33. [2013]
The anode voltage of a photocell is kept fixed. The wavelength λ of the light falling on the cathode is gradually changed. The plate current I of the photocell varies as follows

(A)


(B)


(C)


(D)


34. [2012]
This question has Statement 1 and Statement 2. Of the four choices given after the statements, choose the one that best describes the two statements.
Statement 1: Davisson-Germer experiment established the wave nature of electrons.
Statement 2: If electrons have wave nature, they can interfere and show diffraction.
(A) Statement 1 is true, Statement 2 is false.
(B) Statement 1 is true, Statement 2 is true, Statement 2 is the correct explanation for Statement 1.
(C) Statement 1 is true, Statement 2 is true, Statement 2 is not the correct explanation of Statement 1.
(D) Statement 1 is false, Statement 2 is true.

35. [2011]
This question has Statement-1 and Statement-2. Of the four choices given after the statements, choose the one that best describes the two statements.
Statement-1: A metallic surface is irradiated by a monochromatic light of frequency $\upsilon > \upsilon_0$ (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.
(A) Statement-1 is true, statement-2 is false.
(B) Statement-1 is true, Statement-2 is true, Statement-2 is the correct explanation of Statement-1.
(C) Statement-1 is true, Statement-2 is true, Statement-2 is not the correct explanation of Statement-1.
(D) Statement-1 is false, Statement-2 is true.

36. [2010]
If a source of power 4 kW produces 10^{20} photons/second, the radiation belongs to a part of the spectrum called
(A) γ-rays (B) X-rays
(C) ultraviolet rays (D) microwaves

37. [2010]
This question has Statement-1 and Statement-2. Of the four choices given after the statements, choose the one that best describes the two statements.
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.
(A) Statement-1 is true, Statement-2 is false.
(B) Statement-1 is true, Statement-2 is true; Statement-2 is the correct explanation of Statement-1.
(C) Statement-1 is true, Statement-2 is true; Statement-2 is not the correct explanation of Statement-1.
(D) Statement-1 is false, Statement-2 is true.

38. [2009]
The surface of a metal is illuminated with the light of 400 nm. The kinetic energy of the ejected photoelectrons was found to be 1.68 eV. The work function of the metal is ($hc = 1240$ eV nm)
(A) 3.09 eV (B) 1.41 eV
(C) 1.51 eV (D) 1.68 eV

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Single Correct Choice Type Problems

(In this section each question has four choices (A), (B), (C) and (D), out of which ONLY ONE is correct)

1. **[JEE (Advanced) 2017]**
A photoelectric material having work-function ϕ_0 is illuminated with light of wavelength $\lambda\left(\lambda < \dfrac{hc}{\phi_0}\right)$. The fastest photoelectron has a de-Broglie wavelength λ_d. A change in wavelength of the incident light by $\Delta\lambda$ results in a change $\Delta\lambda_d$ in λ_d. Then, the ratio $\dfrac{\Delta\lambda_d}{\Delta\lambda}$ is proportional to

(A) $\dfrac{\lambda_d^2}{\lambda^2}$ (B) $\dfrac{\lambda_d}{\lambda}$

(C) $\dfrac{\lambda_d^3}{\lambda}$ (D) $\dfrac{\lambda_d^3}{\lambda^2}$

2. **[JEE (Advanced) 2016]**
In a historical experiment to determine Planck's constant, a metal surface was irradiated with light of different wavelengths. The emitted photoelectron energies were measured by applying a stopping potential. The relevant data for the wavelength (λ) of incident light and the corresponding stopping potential (V_0) are given below

λ (μm)	V_0 (Volt)
0.3	2.0
0.4	1.0
0.5	0.4

Given that $c = 3\times10^8\ \text{ms}^{-1}$ and $e = 1.6\times10^{-19}$ C, Planck's constant (in units of Js) found from such an experiment is

(A) 6.0×10^{-34} (B) 6.4×10^{-34}

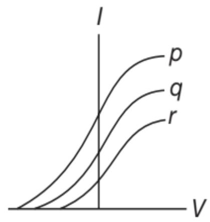
(C) 6.6×10^{-34} (D) 6.8×10^{-34}

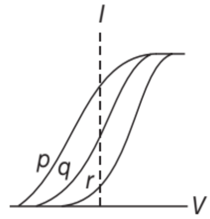
3. **[JEE (Advanced) 2014]**
A metal surface is illuminated by light of two different wavelengths 248 nm and 310 nm. The maximum speed of the photoelectrons corresponding to these wavelengths are μ_1 and μ_2, respectively. If the ratio $\mu_1 : \mu_2 = 2:1$ and $hc = 1240$ eVnm, the work function of the metal is nearly

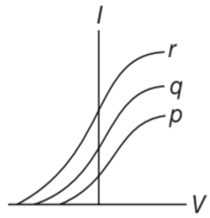
(A) 3.7 eV (B) 3.2 eV

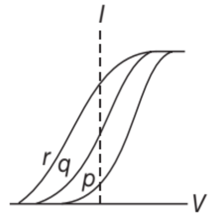
(C) 2.8 eV (D) 2.5 eV

4. **[IIT-JEE 2009]**
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)


5. **[IIT-JEE 2007]**
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

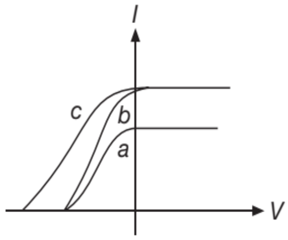
(A) $\lambda_0 = \dfrac{2mc\lambda^2}{h}$ (B) $\lambda_0 = \dfrac{2h}{mc}$

(C) $\lambda_0 = \dfrac{2m^2c^2\lambda^3}{h^2}$ (D) $\lambda_0 = \lambda$

6. **[IIT-JEE 2005]**
A beam of electron is used in an $YDSE$ experiment. The slit width is d. When the velocity of electron is increased, then

(A) no interference is observed
(B) fringe width increases
(C) fringe width decreases
(D) fringe width remains same

7. **[IIT-JEE 2004]**
The figure shows the variation of photocurrent with anode potential for a photosensitive surface for three different radiations. Let I_a, I_b and I_c be the intensities and f_a, f_b and f_c be the frequencies for the curves a, b and c respectively



(A) $f_a = f_b$ and $I_a \neq I_b$ (B) $f_a = f_c$ and $I_a = I_c$
(C) $f_a = f_b$ and $I_a = I_b$ (D) $f_b = f_c$ and $I_b = I_c$

8. [IIT-JEE 2004]
The energy of a photon is equal to the kinetic energy of a proton. The energy of the photon is E. Let λ_1 be the de-Broglie wavelength of the proton and λ_2 be the wavelength of the photon. The ratio $\frac{\lambda_1}{\lambda_2}$ is proportional to

(A) E^o (B) $E^{1/2}$
(C) E^{-1} (D) E^{-2}

9. [IIT-JEE 1999]
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 $\frac{\lambda_1}{\lambda_2}$ is

(A) $\frac{m_1}{m_2}$ (B) $\frac{m_2}{m_1}$
(C) 1 (D) $\sqrt{\frac{m_2}{m_1}}$

10. [IIT-JEE 1998]
The work function of a substance is 4 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

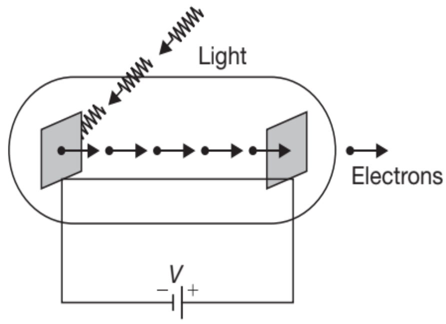
11. [IIT-JEE 1997]
The maximum kinetic energy of photoelectrons emitted from a surface when photons of energy 6 eV fall on it is 4 eV. The stopping potential in volt is

(A) 2 (B) 4
(C) 6 (D) 10

Multiple Correct Choice Type Problems

(In this section each question has four choices (A), (B), (C) and (D), out of which ONE OR MORE is/are correct)

1. [JEE (Advanced) 2016]
Light of wavelength λ_{ph} falls on a cathode plate inside a vacuum tube as shown in the figure. The work function of the cathode surface is ϕ and the anode is a wire mesh of conducting material kept at a distance d from the cathode. A potential difference V is maintained between the electrodes. If the minimum de Broglie wavelength of the electrons passing through the anode is λ_e, which of the following statement(s) is(are) true?



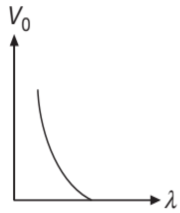
(A) For large potential difference $\left(V \gg \frac{\phi}{e}\right)$, λ_e is approximately halved if V is made four times

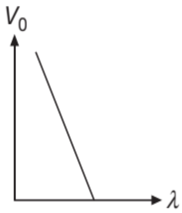
(B) λ_e increases at the same rate as λ_{ph} for $\lambda_{ph} < \frac{hc}{\phi}$

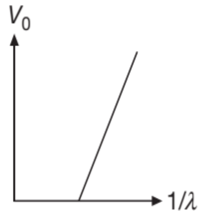
(C) λ_e is approximately halved, if d is doubled

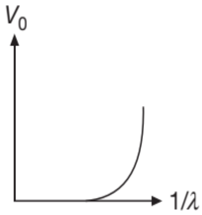
(D) λ_e decreases with increase in ϕ and λ_{ph}

2. [JEE (Advanced) 2015]
For photo-electric effect with incident photon wavelength λ, the stopping potential is V_0. Identify the correct variation(s) of V_0 with λ and $\frac{1}{\lambda}$.

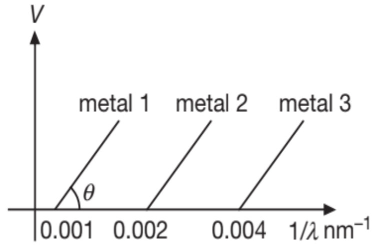
(A)


(B)


(C)


(D)


3. [IIT-JEE 2006]
The graph between $\frac{1}{\lambda}$ and stopping potential (V) of three metals having work functions ϕ_1, ϕ_2 and ϕ_3 in an experiment of photoelectric 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 $\frac{hc}{e}$, where h is Planck's constant and c is the speed of light.

(D) The violet colour light can eject photoelectrons from metals 2 and 3.

4. [IIT-JEE 1994]
When photons of energy 4.25 eV strike the surface of a metal, 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 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.

5. [IIT-JEE 1992]
When a monochromatic point source of light is at a distance of 0.2 m from a photo-electric 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.

6. [IIT-JEE 1987]
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 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.

7. [IIT-JEE 1982]
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 watt infrared lamp

(B) 1 watt infrared lamp

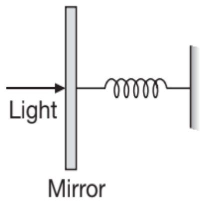
(C) 50 watt ultraviolet lamp

(D) 1 watt ultraviolet lamp

Integer/Numerical Answer Type Questions

(In this section, the answer to each question is a numerical value obtained after series of calculations based on the data provided in the question(s)).

1. [JEE (Advanced) 2019]
A perfectly reflecting mirror of mass M mounted on a spring constitutes a spring-mass system of angular frequency Ω such that $\frac{4\pi M\Omega}{h} = 10^{24}\ \text{m}^{-2}$ with h as Planck's constant, N photons of wavelength $\lambda = 8\pi \times 10^{-6}$ m strike the mirror simultaneously at normal incidence such that the mirror gets displaced by 1 μm. If the value of N is $x \times 10^{12}$, then the value of x is ....
(Consider the spring as massless)



2. [JEE (Advanced) 2018]
In a photoelectric experiment a parallel beam of monochromatic light with power of 200 W is incident on a perfectly absorbing cathode of work function 6.25 eV. The frequency of light is just above the threshold frequency so that the photoelectrons are emitted with negligible kinetic energy. Assume that the photoelectron emission efficiency is 100%. A potential difference of 500 V is applied between the cathode and the anode. All the emitted electrons are incident normally on the anode and are absorbed. The anode experiences a force $F = n \times 10^{-4}$ N due to the impact of the electrons. The value of n is.............. Mass of the electron $m_e = 9 \times 10^{-31}$ kg and $1.0\ \text{eV} = 1.6 \times 10^{-19}$ J.

3. [JEE (Advanced) 2013]
The work functions of Silver and Sodium are 4.6 and 2.3 eV, respectively. Find the ratio of the slope of the stopping potential versus frequency plot for Silver to that of Sodium.

4. [IIT-JEE 2011]

A silver sphere of radius 1 cm and work function 4.7 eV is suspended from an insulting 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 $1 < A < 10$). Find the value of Z.

5. [IIT-JEE 2010]

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

ANSWER KEYS–TEST YOUR CONCEPTS AND PRACTICE EXERCISES

Test Your Concepts-I (Based on Photon Properties)

1. 4.7×10^{-6} Nm^{-2}
2. 453 Å
3. 2.5 Å
4. 2.51×10^{31}
5. 1.43×10^{19}
6. 10^{22}
7. (a) 3.98×10^{-19} J (b) 5×10^{15}
9. 5.5×10^{-12} m
10. $\lambda_e > \lambda_P$
11. $E_p > E_e$
12. $E_p > E_e$
13. 6.66×10^{-9} ms^{-2}
14. 1400 ms^{-1}
15. (a) 2.5×10^{19} photons/sec, (b) 3.33×10^{-8} N
16. 400 nm
17. 1.6×10^{16} photons/sec
18. 3.25 ms^{-1}

Test Your Concepts-II (Based on Photoelectric Effect)

1. 2.8 eV
2. 5×10^{19} photons/s, 1×10^{18} $s^{-1}m^{-2}$, 1.3 eV, 3351 Å
3. 11.93 eV
4. 2260 Å
5. 9.28 mC
6. 1.12×10^{12}
7. (a) 10^{15} Hz (b) 6.25 eV (c) 2 eV
8. 6.6×10^{-34} Js, 5990.25 Å
9. 1.9 eV
10. 1.9 eV, 4125 Å, No change is observed
11. (a) 2.1 eV (b) 2.1 V
12. 5.25 eV, 2357 Å, 3 V
13. (a) 5.4 eV (b) 1.5 eV
14. 4 eV, No
15. (a) 4.5 eV (b) 2.4 eV (c) 9.2×10^{5} ms^{-1}
16. 3.45×10^{-25} $kgms^{-1}$

Single Correct Choice Type Questions

1. C	2. C	3. A	4. B	5. C	6. D	7. B	8. A	9. C	10. C
11. A	12. A	13. C	14. A	15. A	16. B	17. C	18. D	19. C	20. B
21. A	22. A	23. B	24. B	25. C	26. B	27. B	28. D	29. B	30. B
31. C	32. D	33. C	34. D	35. C	36. A	37. C	38. D	39. B	40. B
41. B	42. C	43. B	44. A	45. B	46. C	47. D	48. D	49. B	50. A
51. B	52. D	53. B	54. B	55. D	56. B	57. C	58. D	59. C	60. C
61. B	62. C	63. B	64. A	65. D	66. C	67. A	68. C	69. D	70. C
71. C	72. C	73. A	74. C	75. C	76. B	77. C	78. C	79. A	80. D
81. C	82. C	83. C	84. D	85. A	86. D	87. A	88. C	89. A	90. C
91. D	92. C	93. A	94. C	95. D	96. A	97. C	98. B	99. B	100. A
101. C	102. D	103. D	104. B	105. A	106. A	107. A	108. D	109. C	110. B
111. C	112. A	113. B	114. C	115. B	116. A	117. A	118. D	119. A	120. A
121. B	122. B	123. A	124. A	125. D	126. D	127. A	128. C	129. B	130. A
131. B	132. B	133. B	134. C	135. A	136. D	137. B	138. D	139. D	140. C
141. C	142. B	143. B	144. D	145. B	146. B	147. A	148. C	149. C	150. C
151. A	152. C	153. C	154. A	155. D	156. D				

Multiple Correct Choice Type Questions

1. A, C	**2.** B, D	**3.** A, B, C	**4.** A, B, D	**5.** C, D
6. C, D	**7.** A, B	**8.** A, B, C, D	**9.** A, B, C, D	**10.** A, C, D
11. A, B	**12.** A, B, C, D	**13.** A, B, C	**14.** B, C	**15.** A, B
16. A, B, C	**17.** A, D	**18.** B, D	**19.** B, D	**20.** A, B
21. C, D	**22.** A, C	**23.** C, D	**24.** B, D	**25.** A, D
26. C	**27.** A	**28.** A, B	**29.** A, B	

Reasoning Based Questions

1. A	**2.** A	**3.** C	**4.** B	**5.** D	**6.** D	**7.** C	**8.** D	**9.** D	**10.** C
11. A	**12.** A	**13.** A	**14.** A	**15.** A	**16.** D	**17.** D			

Linked Comprehension Type Questions

1. C	**2.** A	**3.** B	**4.** C	**5.** B	**6.** A	**7.** C	**8.** C	**9.** A	**10.** B
11. A	**12.** C	**13.** B	**14.** D	**15.** B	**16.** D	**17.** D	**18.** A	**19.** A	**20.** A
21. B	**22.** A	**23.** A	**24.** A	**25.** B	**26.** B	**27.** C	**28.** B	**29.** A	**30.** C
31. B									

Matrix Match/Column Match Type Questions

1. A → (p, r)	B → (p, r)	C → (q)	D → (s)		
2. A → (s)	B → (q, s)	C → (p, r)	D → (p, r)		
3. A → (s)	B → (q)	C → (p, r)	D → (p, r)		
4. A → (p, q)	B → (r, s)	C → (q)	D → (p)		
5. A → (q)	B → (s)	C → (p)	D → (t)		
6. A → (p)	B → (r)	C → (s)	D → (q)		
7. A → (p, q)	B → (p, r, s)	C → (p, q)	D → (s)		
8. A → (p, r)	B → (q, s)	C → (s)	D → (p, r)		
9. A → (s)	B → (q)	C → (r, s)	D → (p, r)		
10. A → (q, s)	B → (p, r)	C → (p, r)	D → (s)		
11. A → (r)	B → (s)	C → (p)	D → (u)	E → (q)	F → (t)

Integer/Numerical Answer Type Questions

1. 2	**2.** 20	**3.** 28	**4.** 31	**5.** 148
6. 1	**7.** 300, 1200	**8.** 4	**9.** 5	**10.** 42
11. 2	**12.** 7	**13.** 8	**14.** 10	**15.** 2

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1. D	**2.** C	**3.** A	**4.** A	**5.** A	**6.** D	**7.** D	**8.** C	**9.** D	**10.** C
11. A	**12.** B	**13.** D	**14.** B	**15.** B	**16.** A	**17.** B	**18.** A	**19.** C	**20.** A
21. D	**22.** B	**23.** A	**24.** B	**25.** A	**26.** D	**27.** B	**28.** D	**29.** A	**30.** A
31. C	**32.** B	**33.** D	**34.** B	**35.** D	**36.** B	**37.** A	**38.** B		

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Single Correct Choice Type Problems

1. D	**2.** B	**3.** A	**4.** A	**5.** A	**6.** C	**7.** A	**8.** B	**9.** C	**10.** C
11. B									

Multiple Correct Choice Type Problems

1. A	**2.** A, C	**3.** A, C	**4.** A, B, C	**5.** B, D
6. A, B, C	**7.** C, D			

Integer/Numerical Answer Type Questions

1. 1	**2.** 24.00	**3.** 1	**4.** 8	**5.** 3