Chapter 24

Dual Nature of Radiation and Matter

1. 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 **[AIEEE-2009]**

   (1) 1.41 eV (2) 1.51 eV

   (3) 1.68 eV (4) 3.09 eV

2. 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. **[AIEEE-2010]**

   (1) Statement-1 is true, Statement-2 is false

   (2) Statement-1 is true, Statement-2 is true; Statement-2 is the correct explanation of Statement-1

   (3) Statement-1 is true, Statement-2 is true; Statement-2 is the *not* the correct explanation of Statement-1

   (4) Statement-1 is false, Statement-2 is true

3. If a source of power 4 kW produces 10^{20} photons/second, the radiation belongs to a part of the spectrum called **[AIEEE-2010]**

   (1) γ-rays (2) X-rays

   (3) Ultraviolet rays (4) Microwaves

4. After absorbing a slowly moving neutron of mass m_N (momentum ~ 0) a nucleus of mass M breaks into two nuclei of masses m_1 and $5m_1$ ($6m_1 = M + m_N$), respectively. If the de Broglie wavelength of the nucleus with mass m_1 is λ, the de Broglie wavelength of the other nucleus will be **[AIEEE-2011]**

   (1) λ (2) 25λ

   (3) 5λ (4) $\dfrac{\lambda}{5}$

5. *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. **[AIEEE-2012]**

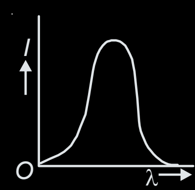
   (1) Statement 1 is true, Statement 2 is false

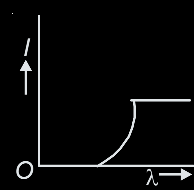
   (2) Statement 1 is true, Statement 2 is true, Statement 2 is the correct explanation for Statement 1

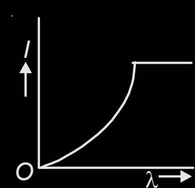
   (3) Statement 1 is true, Statement 2 is true, Statement 2 is not the correct explanation of Statement 1

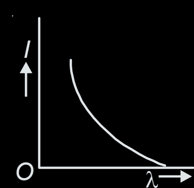
   (4) Statement 1 is false, Statement 2 is true

6. 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 **[JEE (Main)-2013]**

   (1) 

   (2) 

   (3) 

   (4) 

7. The radiation corresponding to $3\rightarrow2$ transition of hydrogen atoms falls on a metal surface to produce photoelectrons. These electrons are made to enter a magnetic field of 3×10^{-4} T. If the radius of the largest circular path followed by these electrons is 10.0 mm, the work function of the metal is close to **[JEE (Main)-2014]**

   (1) 1.8 eV (2) 1.1 eV

   (3) 0.8 eV (4) 1.6 eV

8. Match List-I (Fundamental Experiment) with List-II (its conclusion) and select the correct option from the choices given below the list:

	List -I		List-II
(A)	Franck-Hertz experiment	(i)	Particle nature of light
(B)	Photo-electric experiment	(ii)	Discrete energy levels of atom
(C)	Davison-Germer experiment	(iii)	Wave nature of electron
		(iv)	Structure of atom

[JEE (Main)-2015]

(1) (A) - (i) (B) - (iv) (C) - (iii)

(2) (A) - (ii) (B) - (iv) (C) - (iii)

(3) (A) - (ii) (B) - (i) (C) - (iii)

(4) (A) - (iv) (B) - (iii) (C) - (ii)

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

(1) $< v\left(\frac{4}{3}\right)^{\frac{1}{2}}$ (2) $= v\left(\frac{4}{3}\right)^{\frac{1}{2}}$

(3) $= v\left(\frac{3}{4}\right)^{\frac{1}{2}}$ (4) $> v\left(\frac{4}{3}\right)^{\frac{1}{2}}$

10. 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 **[JEE (Main)-2017]**

(1) $\frac{\lambda_A}{\lambda_B} = \frac{1}{3}$ (2) $\frac{\lambda_A}{\lambda_B} = 2$

(3) $\frac{\lambda_A}{\lambda_B} = \frac{2}{3}$ (4) $\frac{\lambda_A}{\lambda_B} = \frac{1}{2}$

11. Surface of certain metal is first illuminated with light of wavelength λ_1 = 350 nm and then, by light of wavelength λ_2 = 540 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 **[JEE (Main)-2019]**

(Energy of photon = $\frac{1240}{\lambda(\text{in nm})}$ eV)

(1) 1.8 (2) 5.6

(3) 2.5 (4) 1.4

12. 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 7.5×10^{-12} m, the minimum electron energy required is close to **[JEE (Main)-2019]**

(1) 100 keV (2) 1 keV

(3) 500 keV (4) 25 keV

13. A metal plate of area 1×10^{-4} m^2 is illuminated by a radiation of intensity 16 mW/m^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 [1 eV = 1.6×10^{-19} J] **[JEE (Main)-2019]**

(1) 10^{14} and 10 eV (2) 10^{11} and 5 eV

(3) 10^{10} and 5 eV (4) 10^{12} and 5 eV

14. 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 **[JEE (Main)-2019]**

(Speed of light = 3×10^8 m/s

Planck's constant = 6.63×10^{-34} J-s

Mass of electron = 9.1×10^{-31} kg)

(1) 1.7×10^6 m/s (2) 1.45×10^6 m/s

(3) 1.8×10^6 m/s (4) 1.1×10^6 m/s

15. 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 $\left(\frac{hc}{e} = 1240\ \text{nm-V}\right)$

[JEE (Main)-2019]

(1) 1.0 V (2) 2.0 V

(3) 1.5 V (4) 0.5 V

16. A particle A of mass m and charge 'q' is accelerated by a potential difference of 50 V. Another particle B of mass $4m$ 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

[JEE (Main)-2019]

(1) 0.07 (2) 14.14

(3) 4.47 (4) 10.00

17. When a certain photosensistive 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 photoeletric emission is **[JEE (Main)-2019]**

(1) $\frac{3\nu}{2}$ (2) $\frac{4}{3}\nu$

(3) $\frac{5\nu}{3}$ (4) 2ν

18. 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 **[JEE (Main)-2019]**

(1) 1700 nm (2) 2020 nm

(3) 250 nm (4) 220 nm

19. 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 **[JEE (Main)-2019]**

(1) $\lambda = \sqrt{\lambda_1\lambda_2}$ (2) $\lambda = \frac{\lambda_1+\lambda_2}{2}$

(3) $\frac{2}{\lambda} = \frac{1}{\lambda_1}+\frac{1}{\lambda_2}$ (4) $\frac{1}{\lambda^2} = \frac{1}{\lambda_1^2}+\frac{1}{\lambda_2^2}$

20. The electric field of light wave is given as $\vec{E} = 10^{-3}\cos\left(\frac{2\pi x}{5\times10^{-7}} - 2\pi\times6\times10^{14}t\right)\hat{x}\ \frac{\text{N}}{\text{C}}$. This light falls on a metal plate of work function 2 eV. The stopping potential of the photo-electrons is :

Given, E (in eV) = $\frac{12375}{\lambda\text{ (in Å)}}$ **[JEE (Main)-2019]**

(1) 0.48 V (2) 2.48 V

(3) 0.72 V (4) 2.0 V

21. 50 W/m^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 ($c = 3 \times 10^8$ m/s) **[JEE (Main)-2019]**

(1) 20×10^{-8} N (2) 35×10^{-8} N

(3) 15×10^{-8} N (4) 10×10^{-8} N

22. 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 **[JEE (Main)-2019]**

(1) $\frac{\lambda_x\lambda_y}{|\lambda_x-\lambda_y|}$ (2) $\lambda_x-\lambda_y$

(3) $\lambda_x+\lambda_y$ (4) $\frac{\lambda_x\lambda_y}{\lambda_x+\lambda_y}$

23. 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 (in eV) = $\frac{1237}{\lambda\text{(in nm)}}$ **[JEE (Main)-2019]**

(1) 4.5 eV (2) 15.1 eV

(3) 3.0 eV (4) 1.5 eV

24. A 2 mW laser operates at a wavelength of 500 nm. The number of photons that will be emitted per second is: **[JEE (Main)-2019]**

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

(1) 2×10^{16} (2) 1.5×10^{16}

(3) 1×10^{16} (4) 5×10^{15}

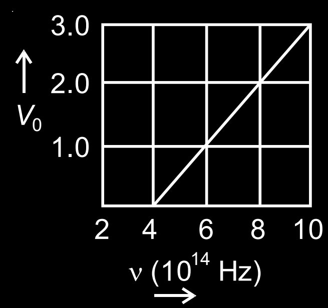
25. Light is incident normally on a completely absorbing surface with an energy flux of 25 Wcm^{-2}. If the surface has an area of 25 cm^2, the momentum transferred to the surface in 40 min time duration will be **[JEE (Main)-2019]**

(1) 3.5×10^{-6} Ns (2) 6.3×10^{-4} Ns

(3) 5.0×10^{-3} Ns (4) 1.4×10^{-6} Ns

26. 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: **[JEE (Main)-2019]**

(Given: Planck's constant (h) = 6.63×10^{-34} Js, electron charge $e = 1.6 \times 10^{-19}$ C)



(1) 1.95 eV (2) 2.12 eV

(3) 1.82 eV (4) 1.66 eV

27. A polarizer-analyser set is adjusted such that the intensity of light coming out of the analyser is just 10% of the original intensity. Assuming the polarizer - analyser set does not absorb any light, the angle by which the analyser need to be rotated further to reduced the output intensity to be zero, is

[JEE (Main)-2020]

(1) 71.6° (2) 45°

(3) 90° (4) 18.4°

28. An electron (of mass m) and a photon have the same energy E in the range of a few eV. The ratio of the de-Broglie wavelength associated with the electron and the wavelength of the photon is (c = speed of light in vacuum) **[JEE (Main)-2020]**

(1) $\frac{1}{c}\left(\frac{E}{2m}\right)^{\frac{1}{2}}$ (2) $\left(\frac{E}{2m}\right)^{\frac{1}{2}}$

(3) $c(2mE)^{\frac{1}{2}}$ (4) $\frac{1}{c}\left(\frac{2E}{m}\right)^{\frac{1}{2}}$

29. When photon of energy 4.0 eV strikes the surface of a metal A, the ejected photoelectrons have maximum kinetic energy T_A eV and de-Broglie wavelength λ_A.The maximum kinetic energy of photoelectrons liberated from another metal B by photon of energy 4.50 eV is $T_B = (T_A - 1.5)$ eV. If the de-Broglie waelength of these photoelectrons $\lambda_B = 2\lambda_A$, then the work function of metal B is

[JEE (Main)-2020]

(1) 1.5 eV (2) 4 eV

(3) 3 eV (4) 2 eV

30. The dimension of stopping potential V_0 in photoelectric effect in units of Planck's constant 'h', speed of light 'c' and Gravitational constant 'G' and ampere A is **[JEE (Main)-2020]**

(1) $h^{1/3}G^{2/3}c^{1/3}A^{-1}$ (2) $h^{2/3}c^{5/3}G^{1/3}A^{-1}$

(3) $h^0G^{-1}C^5A^{-1}$ (4) $h^2G^{3/2}c^{1/3}A^{-1}$

31. An electron (mass m) with initial velocity $\vec{v} = v_0\hat{i} + v_0\hat{j}$ is in an electric field $\vec{E} = -E_0\hat{k}$. If λ_0 is initial de-Broglie wavelength of electron, its de-Broglie wavelength at time t is given by

[JEE (Main)-2020]

(1) $\dfrac{\lambda_0}{\sqrt{1+\dfrac{e^2E_0^2t^2}{m^2v_0^2}}}$ (2) $\dfrac{\lambda_0\sqrt{2}}{\sqrt{1+\dfrac{e^2E^2t^2}{m^2v_0^2}}}$

(3) $\dfrac{\lambda_0}{\sqrt{1+\dfrac{e^2E^2t^2}{2m^2v_0^2}}}$ (4) $\dfrac{\lambda_0}{\sqrt{2+\dfrac{e^2E^2t^2}{m^2v_0^2}}}$

32. A particle moving with kinetic energy E has de Broglie wavelength λ. If energy ΔE is added to its energy, the wavelength become $\lambda/2$. Value of ΔE, is **[JEE (Main)-2020]**

(1) $4E$ (2) E

(3) $2E$ (4) $3E$

33. Radiation, with wavelength 6561 Å falls on a metal surface to produce photoelectrons. The electrons are made to enter a uniform magnetic field of 3×10^{-4} T. If the radius of the largest circular path followed by the electrons is 10 mm, the work function of the metal is close to **[JEE (Main)-2020]**

(1) 1.6 eV (2) 1.1 eV

(3) 0.8 eV (4) 1.8 eV

34. An electron of mass m and magnitude of 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 is **[JEE (Main)-2020]**

(1) $-\frac{h}{|e|E\sqrt{t}}$ (2) $\frac{-h}{|e|Et^2}$

(3) $\frac{|e|Et}{h}$ (4) $-\frac{h}{|e|Et}$

35. A particle is moving 5 times as fast as an electron. The ratio of the de-Broglie wavelength of the particle to that of the electron is 1.878×10^{-4}. The mass of the particle is close to

[JEE (Main)-2020]

(1) 1.2×10^{-28} kg (2) 9.1×10^{-31} kg

(3) 4.8×10^{-27} kg (4) 9.7×10^{-28} kg

36. When the wavelength of radiation falling on a metal is changed from 500 nm to 200 nm, the maximum kinetic energy of the photoelectrons becomes three times larger. The work function of the metal is close to **[JEE (Main)-2020]**

(1) 0.52 eV (2) 1.02 eV

(3) 0.61 eV (4) 0.81 eV

37. Two sources of light emit X-rays of wavelength 1 nm and visible light of wavelength 500 nm, respectively. Both the sources emit light of the same power 200 W. The ratio of the number density of photons of X-rays to the number density of photons of the visible light of the given wavelengths is **[JEE (Main)-2020]**

(1) $\frac{1}{250}$ (2) $\frac{1}{500}$

(3) 500 (4) 250

38. Particle A of mass $m_A = \frac{m}{2}$ moving along the x-axis with velocity v_0 collides elastically with another particle B at rest having mass $m_B = \frac{m}{3}$. If both particles move along the x-axis after the collision, the change $\Delta\lambda$ in de-Broglie wavelength of particle A, in terms of its de-Broglie wavelength (λ_0) before collision is **[JEE (Main)-2020]**

(1) $\Delta\lambda = 2\lambda_0$

(2) $\Delta\lambda = 4\lambda_0$

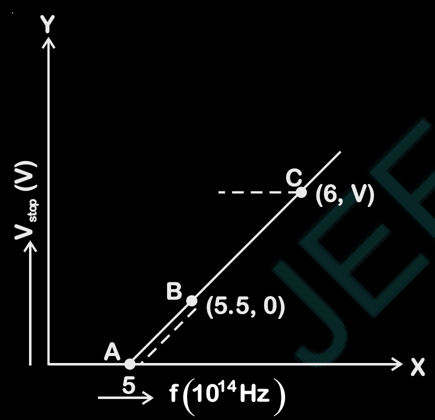
(3) $\Delta\lambda = \frac{3}{2}\lambda_0$

(4) $\Delta\lambda = \frac{5}{2}\lambda_0$

39. Given figure shows few data points in a photo electric effect experiment for a certain metal. The minimum energy for ejection of electron from its surface is

(Plancks constant $h = 6.62 \times 10^{-34}$ J.s)

[JEE (Main)-2020]



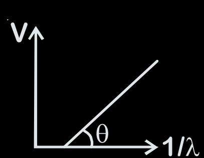
(1) 2.59 eV

(2) 2.27 eV

(3) 1.93 eV

(4) 2.10 eV

40. In a photoelectric effect experiment, the graph of stopping potential V versus reciprocal of wavelength obtained is shown in the figure. As the intensity of incident radiation is increased **[JEE (Main)-2020]**



(1) Slope of the straight line get more steep

(2) Graph does not change

(3) Straight line shifts to left

(4) Straight line shifts to right

41. With increasing biasing voltage of a photodiode, the photocurrent magnitude **[JEE (Main)-2020]**

(1) Increases initially and after attaining certain value, it decreases

(2) Increases linearly

(3) Increases initially and saturates finally

(4) Remains constant

42. An electron, a doubly ionized helium ion (He^{++}) and a proton are having the same kinetic energy. The relation between their respective de-Broglie wavelengths λ_e, $\lambda_{He^{++}}$ and λ_p is

[JEE (Main)-2020]

(1) $\lambda_e > \lambda_{He^{++}} > \lambda_p$

(2) $\lambda_e < \lambda_p < \lambda_{He^{++}}$

(3) $\lambda_e > \lambda_p > \lambda_{He^{++}}$

(4) $\lambda_e < \lambda_{He^{++}} = \lambda_p$

43. Assuming the nitrogen molecule is moving with r.m.s. velocity at 400 K, the de-Broglie wavelength of nitrogen molecule is close to

(Given : nitrogen molecule weight : 4.64×10^{-26} kg, Boltzman constant : 1.38×10^{-23} J/K, Planck constant : 6.63×10^{-34} J.s) **[JEE (Main)-2020]**

(1) 0.24 Å

(2) 0.20 Å

(3) 0.34 Å

(4) 0.44 Å

44. When radiation of wavelength λ is used to illuminate a metallic surface, the stopping potential is V. When the same surface is illuminated with radiation of wavelength 3λ, the stopping potential is $\frac{V}{4}$. If the threshold wavelength for the metallic surface is $n\lambda$ then value of n will be ________.

[JEE (Main)-2020]

45. The surface of a metal is illuminated alternately with photons of energies E_1 = 4 eV and E_2 = 2.5 eV respectively. The ratio of maximum speeds of the photoelectrons emitted in the two cases is 2. The work function of the metal in (eV) is _____.

[JEE (Main)-2020]

46. Given below are two statements:

Statement I : Two photons having equal linear momenta have equal wavelengths

Statement II : If the wavelength of photon is decreased, then the momentum and energy of a photon will also decrease

In the light of the above statements, choose the correct answer from the options given below

[JEE (Main)-2021]

(1) Statement I is true but Statement II is false

(2) Both Statement I and Statement II are false

(3) Statement I is false but Statement II is true

(4) Both Statement I and Statement II are true

47. The de Broglie wavelength of a proton and α-particle are equal. The ratio of their velocities is

[JEE (Main)-2021]

(1) 1 : 4
(2) 4 : 3
(3) 4 : 1
(4) 4 : 2

48. An α particle and a proton are accelerated from rest by a potential difference of 200 V. After this, de Broglie wavelengths are λ_α and λ_P respectively. The ratio $\frac{\lambda_P}{\lambda_\alpha}$ is : **[JEE (Main)-2021]**

(1) 8
(2) 2.8
(3) 3.8
(4) 7.8

49. An electron of mass m_e and a proton of mass $m_p = 1836m_e$ are moving with the same speed. The ratio of their de Broglie wavelength $\frac{\lambda_{electron}}{\lambda_{proton}}$ will be **[JEE (Main)-2021]**

(1) $\frac{1}{1836}$
(2) 918
(3) 1
(4) 1836

50. The stopping potential for electrons emitted from a photosensitive surface illuminated by light of wavelength 491 nm is 0.710 V. When the incident wavelength is changed to a new value, the stopping potential is 1.43 V. The new wavelength is:

[JEE (Main)-2021]

(1) 329 nm
(2) 400 nm
(3) 382 nm
(4) 309 nm

51. Two stream of photons, possessing energies equal to twice and ten times the work function of metal are incident on the metal surface successively. The value of ratio of maximum velocities of the photoelectrons emitted in the two respective cases is x : 3. The value of x is _________.

[JEE (Main)-2021]

52. The stopping potential in the context of photoelectric effect depends on the following property of incident electromagnetic radiation:

[JEE (Main)-2021]

(1) Intensity
(2) Amplitude
(3) Frequency
(4) Phase

53. The de-Broglie wavelength associated with an electron and a proton were calculated by accelerating them through same potential of 100 V. What should nearly be the ratio of their wavelengths? (m_p = 1.00727u, m_e = 0.00055u)

[JEE (Main)-2021]

(1) 41.4 : 1
(2) $(1860)^2$: 1
(3) 1860 : 1
(4) 43 : 1

54. An electron of mass m and a photon have same energy E. The ratio of wavelength of electron to that of photon is: (c being the velocity of light)

[JEE (Main)-2021]

(1) $c(2mE)^{\frac{1}{2}}$
(2) $\left(\frac{E}{2m}\right)^{\frac{1}{2}}$
(3) $\frac{1}{c}\left(\frac{E}{2m}\right)^{\frac{1}{2}}$
(4) $\frac{1}{c}\left(\frac{2m}{E}\right)^{\frac{1}{2}}$

55. Two identical photocathodes receive the light of frequencies f_1 and f_2 respectively. If the velocities of the photo-electrons coming out are v_1 and v_2 respectively, then **[JEE (Main)-2021]**

(1) $v_1^2 + v_2^2 = \frac{2h}{m}[f_1 + f_2]$

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

(3) $v_1 + v_2 = \left[\frac{2h}{m}(f_1 + f_2)\right]^{\frac{1}{2}}$

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

56. A particle is travelling 4 times as fast as an electron. Assuming the ratio of de-Broglie wavelength of a particle to that of electron is 2 : 1, the mass of the particle is **[JEE (Main)-2021]**

(1) 16 times the mass of e^-

(2) 8 times the mass of e^-

(3) $\frac{1}{16}$ times the mass of e^-

(4) $\frac{1}{8}$ times the mass of e^-

57. The speed of electrons in a scanning electron microscope is 1×10^7 ms^{-1}. If the protons having the same speed are used instead of electrons, then the resolving power of scanning proton microscope will be changed by a factor of **[JEE (Main)-2021]**

(1) $\frac{1}{\sqrt{1837}}$ (2) $\frac{1}{1837}$

(3) $\sqrt{1837}$ (4) 1837

58. The radiation corresponding to $3 \rightarrow 2$ transition of a hydrogen atom falls on a gold surface to generate photoelectrons. These electrons are passed through a magnetic field of 5×10^{-4} T. Assume that the radius of the largest circular path followed by these electrons is 7 mm, the work function of the metal is : (Mass of electron = 9.1 $\times 10^{-31}$ kg) **[JEE (Main)-2021]**

(1) 1.36 eV (2) 1.88 eV

(3) 0.82 eV (4) 0.16 eV

59. A certain metallic surface is illuminated by monochromatic radiation of wavelength λ. The stopping potential for photoelectric current for this radiation is $3V_0$. If the same surface is illuminated with a radiation of wavelength 2λ, the stopping potential is V_0. The threshold wavelength of this surface for photoelectric effect is ______ λ.

[JEE (Main)-2021]

60. An electron of mass m_e and a proton of mass m_p are accelerated through the same potential difference. The ratio of the de-Broglie wavelength associated with the electron to that with the proton is **[JEE (Main)-2021]**

(1) $\frac{m_e}{m_p}$ (2) 1

(3) $\frac{m_p}{m_e}$ (4) $\sqrt{\frac{m_p}{m_e}}$

61. What should be the order of arrangement of de-Broglie wavelength of electron (λ_e), an α-particle (λ_α) and proton (λ_p) given that all have the same kinetic energy? **[JEE (Main)-2021]**

(1) $\lambda_e = \lambda_p > \lambda_\alpha$ (2) $\lambda_e = \lambda_p = \lambda_\alpha$

(3) $\lambda_e > \lambda_p > \lambda_\alpha$ (4) $\lambda_e < \lambda_p < \lambda_\alpha$

62. A particle of mass 4M at rest disintegrates into two particles of mass M and 3M respectively having non zero velocities. The ratio of de-Broglie wavelength of particle of mass M to that of mass 3M will be: **[JEE (Main)-2021]**

(1) 1 : 3 (2) $1 : \sqrt{3}$

(3) 1 : 1 (4) 3 : 1

63. When radiation of wavelength λ is incident on a metallic surface, the stopping potential of ejected photoelectrons is 4.8 V. If the same surface is illuminated by radiation of double the previous wavelength, then the stopping potential becomes 1.6 V. The threshold wavelength of the metal is

[JEE (Main)-2021]

(1) 6λ (2) 4λ

(3) 8λ (4) 2λ

64. An electron moving with speed v and a photon moving with speed c, have same de-Broglie wavelength. The ratio of kinetic energy of electron to that of photon is **[JEE (Main)-2021]**

(1) $\frac{v}{3c}$ (2) $\frac{v}{2c}$

(3) $\frac{3c}{v}$ (4) $\frac{2c}{v}$

65. A light beam of wavelength 500 nm is incident on a metal having work function of 1.25 eV, placed in a magnetic field of intensity B. The electrons emitted perpendicular to the magnetic field B, with maximum kinetic energy, are bent into circular arc of radius 30 cm. The value of B is ____ $\times 10^{-7}$ T.

Given hc = 20×10^{-26} J-m, mass of electron = 9×10^{-31} kg **[JEE (Main)-2021]**

66. A particle of mass 9.1×10^{-31} kg travels in a medium with a speed of 10^6 m/s and a photon of a radiation of linear momentum 10^{-27} kg m/s travels in vacuum. The wavelength of photon is ______ times the wavelength of the particle.

[JEE (Main)-2021]

67. An electron and proton are separated by a large distance. The electron starts approaching the proton with energy 3 eV. The proton captures the electron and forms a hydrogen atom in second excited state. The resulting photon is incident on a photosensitive metal of threshold wavelength 4000 Å. What is the maximum kinetic energy of the emitted photoelectron? **[JEE (Main)-2021]**

(1) 3.3 eV

(2) No photoelectron would be emitted

(3) 1.41 eV

(4) 7.61 eV

68. In a photoelectric experiment, ultraviolet light of wavelength 280 nm is used with lithium cathode having work function $\phi = 2.5$ eV. If the wavelength of incident light is switched to 400 nm, find out the change in the stopping potential.

($h = 6.63 \times 10^{-34}$ Js, $c = 3 \times 10^8$ ms^{-1})

[JEE (Main)-2021]

(1) 1.1 V (2) 0.6 V

(3) 1.9 V (4) 1.3 V

69. The electric field in a plane electromagnetic wave is given by **[JEE (Main)-2021]**

$$\vec{E} = 200\cos\left[\left(\frac{0.5\times10^3}{m}\right)x - \left(1.5\times10^{11}\,\frac{rad}{s}\times t\right)\right]\frac{V}{m}\hat{j}$$

If this wave falls normally on a perfectly reflecting surface having an area of 100 cm^2. If the radiation pressure exerted by the E.M. wave on the surface during a 10 minute exposure is $\frac{x}{10^9}\frac{N}{m^2}$. Find the value of x.

70. The de-Broglie wavelength of a particle having kinetic energy E is λ. How much extra energy must be given to this particle so that the de-Broglie wavelength reduces to 75% of the initial value?

[JEE (Main)-2021]

(1) $\frac{7}{9}E$ (2) $\frac{1}{9}E$

(3) E (4) $\frac{16}{9}E$

71. In a photoelectric experiment, increasing the intensity of incident light: **[JEE (Main)-2021]**

(1) Increases the frequency of photons incident and the K.E. of the ejected electrons remains unchanged.

(2) Increases the frequency of photons incident and increases the K.E. of the ejected electrons.

(3) Increases the number of photons incident and also increases the K.E. of the ejected electrons.

(4) Increases the number of photons incident and the K.E. of the ejected electrons remains unchanged.

72. A monochromatic neon lamp with wavelength of 670.5 nm illuminates a photo-sensitive material which has a stopping voltage of 0.48 V. What will be the stopping voltage if the source light is changed with another source of wavelength of 474.6 nm? **[JEE (Main)-2021]**

(1) 0.96 V

(2) 1.25 V

(3) 1.5 V

(4) 0.24 V

73. A moving proton and electron have the same de-Broglie wavelength. If K and P denote the K.E. and momentum respectively. Then choose the correct option: **[JEE (Main)-2021]**

(1) $K_P = K_e$ and $P_P = P_e$

(2) $K_P < K_e$ and $P_P < P_e$

(3) $K_P < K_e$ and $P_P = P_e$

(4) $K_P > K_e$ and $P_P = P_e$

74. The temperature of an ideal gas in 3-dimensions is 300 K. The corresponding de-Broglie wavelength of the electron approximately at 300 K, is:

[JEE (Main)-2021]

[m_e = mass of electron = 9×10^{-31} kg

h = Planck constant = 6.6×10^{-34} J s

k_B = Boltzmann constant = 1.38×10^{-23} JK^{-1}]

(1) 2.26 nm

(2) 6.26 nm

(3) 8.46 nm

(4) 3.25 nm

75. When light of frequency twice the threshold frequency is incident on the metal plate, the maximum velocity of emitted electron is v_1. When the frequency of incident radiation is increased to five times the threshold value, the maximum velocity of emitted electron becomes v_2.

If $v_2 = x\,v_1$, the value of x will be ________.

[JEE (Main)-2022]

76. Given below are two statements :

Statement I: Davisson-Germer experiment establishes the wave nature of electrons.

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

In the light of the above statements choose the correct answer from the option given below :

[JEE (Main)-2022]

(1) Both statement I and statement II are true.

(2) Both statement I and statement II are false.

(3) Statement I is true but statement II is false.

(4) Statement I is false but statement II is true.

77. A proton, a neutron, an electron and an α-particle have same energy. If λ_p, λ_n, λ_e and λ_α are the de Broglie's wavelengths of proton, neutron, electron and α particle respectively, then choose the correct relation from the following:

[JEE (Main)-2022]

(1) $\lambda_p = \lambda_n > \lambda_e > \lambda_\alpha$ (2) $\lambda_\alpha < \lambda_n < \lambda_p < \lambda_e$

(3) $\lambda_e < \lambda_p = \lambda_n > \lambda_\alpha$ (4) $\lambda_e = \lambda_p = \lambda_n = \lambda_\alpha$

78. An electron with speed υ and a photon with speed c have the same de-Broglie wavelength. If the kinetic energy and momentum of electron are E_e and p_e and that of photon are E_{ph} and p_{ph} respectively. Which of the following is correct?

[JEE (Main)-2022]

(1) $\frac{E_e}{E_{ph}} = \frac{2c}{\upsilon}$ (2) $\frac{E_e}{E_{ph}} = \frac{\upsilon}{2c}$

(3) $\frac{p_e}{p_{ph}} = \frac{2c}{\upsilon}$ (4) $\frac{p_e}{p_{ph}} = \frac{\upsilon}{2c}$

79. An α particle and a carbon 12 atom has same kinetic energy K. The ratio of their de-Broglie wavelengths ($\lambda_\alpha : \lambda_{C12}$) is **[JEE (Main)-2022]**

(1) $1:\sqrt{3}$ (2) $\sqrt{3}:1$

(3) 3:1 (4) $2:\sqrt{3}$

80. The de Broglie wavelengths for an electron and a photon are λ_e and λ_p respectively. For the same kinetic energy of electron and photon, which of the following presents the correct relation between the de Broglie wavelengths of two?

[JEE (Main)-2022]

(1) $\lambda_p \propto \lambda_e^2$ (2) $\lambda_p \propto \lambda_e$

(3) $\lambda_p \propto \sqrt{\lambda_e}$ (4) $\lambda_p \propto \sqrt{\frac{1}{\lambda_e}}$

81. Let K_1 and K_2 be the maximum kinetic energies of photo-electrons emitted when two monochromatic beams of wavelength λ_1 and λ_2, respectively are incident on a metallic surface. If $\lambda_1 = 3\lambda_2$ then:

[JEE (Main)-2022]

(1) $K_1 > \frac{K_2}{3}$ (2) $K_1 < \frac{K_2}{3}$

(3) $K_1 = \frac{K_2}{3}$ (4) $K_2 = \frac{K_1}{3}$

82. Given below are two statements : one is labelled as **Assertion A** and the other is labelled as **Reason R.**

Assertion A : The photoelectric effect does not take place, if the energy of the incident radiation is less than the work function of a metal.

Reason R : Kinetic energy of the photoelectrons is zero, if the energy of the incident radiation is equal to the work function of a metal.

In the light of the above statements, choose the **most appropriate** answer from the options given below. **[JEE (Main)-2022]**

(1) Both **A** and **R** are correct and **R** is the correct explanation of **A**

(2) Both **A** and **R** are correct but **R** is **not** the correct explanation of **A**

(3) **A** is correct but **R** is not correct

(4) **A** is not correct but **R** is correct

83. The electric field at a point associated with a light wave is given by

$E = 200[\sin(6 \times 10^{15})t + \sin(9 \times 10^{15})t]$ Vm^{-1}

Given : $h = 4.14 \times 10^{-15}$ eVs

If this light falls on a metal surface having a work function of 2.50 eV, the maximum kinetic energy of the photoelectrons will be

[JEE (Main)-2022]

(1) 1.90 eV

(2) 3.27 eV

(3) 3.60 eV

(4) 3.42 eV

84. A metal exposed to light of wavelength 800 nm and emits photoelectrons with a certain kinetic energy. The maximum kinetic energy of photo-electron doubles when light of wavelength 500 nm is used. The workfunction of the metal is:

(Take hc = 1230 eV-nm) **[JEE (Main)-2022]**

(1) 1.537 eV

(2) 2.46 eV

(3) 0.615 eV

(4) 1.23 eV

85. The ratio of wavelengths of proton and deuteron accelerated by potential V_p and V_d is $1:\sqrt{2}$. Then, the ratio of V_p to V_d will be:

[JEE (Main)-2022]

(1) 1 : 1 (2) $\sqrt{2}:1$

(3) 2 : 1 (4) 4 : 1

86. A parallel beam of light of wavelength 900 nm and intensity 100 Wm^{-2} is incident on a surface perpendicular to the beam. The number of photons crossing 1 cm^{-2} area perpendicular to the beam in one second is **[JEE (Main)-2022]**

(1) 3×10^{16}

(2) 4.5×10^{16}

(3) 4.5×10^{17}

(4) 4.5×10^{20}

87. An electron (mass m) with an initial velocity $\vec{v} = v_0\hat{i}\,(v_0 > 0)$ is moving in an electric field $\vec{E} = E_0\hat{i}\,(E_0 > 0)$ where E_0 is constant. If at $t = 0$ de-Broglie wavelength is $\lambda_0 = \frac{h}{mv_0}$, then its de-Broglie wavelength after time t is given by

[JEE (Main)-2022]

(1) λ_0 (2) $\lambda_0\left(1+\frac{eE_0t}{mv_0}\right)$

(3) $\lambda_0 t$ (4) $\frac{\lambda_0}{\left(1+\frac{eE_0t}{mv_0}\right)}$

88. With reference to the observations in photo-electric effect, identify the correct statements from below:

[JEE (Main)-2022]

(A) The square of maximum velocity of photoelectrons varies linearly with frequency of incident light.

(B) The value of saturation current increases on moving the source of light away from the metal surface.

(C) The maximum kinetic energy of photo-electrons decreases on decreasing the power of LED (Light emitting diode) source of light.

(D) The immediate emission of photo-electrons out of metal surface can not be explained by particle nature of light/electromagnetic waves.

(E) Existence of threshold wavelength can not be explained by wave nature of light/electromagnetic waves.

Choose the correct answer from the options given below.

(1) (A) and (B) only

(2) (A) and (E) only

(3) (C) and (E) only

(4) (D) and (E) only

89. Sun light falls normally on a surface of area 36 cm^2 and exerts an average force of 7.2×10^{-9} N within a time period of 20 minutes. Considering a case of complete absorption, the energy flux of incident light is **[JEE (Main)-2022]**

(1) 25.92×10^2 W/cm^2

(2) 8.64×10^{-6} W/cm^2

(3) 6.0 W/cm^2

(4) 0.06 W/cm^2

90. Two streams of photons, possessing energies equal to five and ten times the work function of metal are incident on the metal surface successively. The ratio of maximum velocities of the photoelectron emitted, in the two cases respectively, will be **[JEE (Main)-2022]**

(1) 1 : 2

(2) 1 : 3

(3) 2 : 3

(4) 3 : 2

91. The kinetic energy of emitted electron is E when the light incident on the metal has wavelength λ. To double the kinetic energy, the incident light must have wavelength : **[JEE (Main)-2022]**

(1) $\frac{hc}{E\lambda - hc}$

(2) $\frac{hc\lambda}{E\lambda + hc}$

(3) $\frac{h\lambda}{E\lambda + hc}$

(4) $\frac{hc\lambda}{E\lambda - hc}$

92. A nucleus of mass M at rest splits into two parts having masses $\frac{M'}{3}$ and $\frac{2M'}{3}(M' < M)$. The ratio of de Broglie wavelength of two parts will be: **[JEE (Main)-2022]**

(1) 1 : 2 (2) 2 : 1

(3) 1 : 1 (4) 2 : 3

93. A metal surface is illuminated by a radiation of wavelength 4500 Å. The rejected photo-electron enters a constant magnetic field of 2 mT making an angle of 90° with the magnetic field. If it starts revolving in a circular path of radius 2 mm, the work function of the metal is approximately: **[JEE (Main)-2022]**

(1) 1.36 eV (2) 1.69 eV

(3) 2.78 eV (4) 2.23 eV

94. The light of two different frequencies whose photons have energies 3.8 eV and 1.4 eV respectively, illuminate a metallic surface whose work function is 0.6 eV successively. The ratio of maximum speeds of emitted electrons for the two frequencies respectively will be **[JEE (Main)-2022]**

(1) 1 : 1 (2) 2 : 1

(3) 4 : 1 (4) 1 : 4

95. The stopping potential for photoelectrons emitted from a surface illuminated by light of wavelength 6630 Å is 0.42 V. If the threshold frequency is $x \times 10^{13}$/s, where x is ____ (nearest integer).

(Given, speed of light = 3×10^8 m/s, Planck's constant = 6.63×10^{-34} Js) **[JEE (Main)-2022]**

❑ ❑ ❑

Chapter 24

Dual Nature of Radiation and Matter

1. Answer (1)

According to Einstein photo electric equation

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

$\Rightarrow$ (3.10 eV – 1.68 eV) = K_{max}

$\Rightarrow$ K_{max} = 1.42 eV

2. Answer (1)

X-rays frequency is more than that of UV rays. So, KE_{max} and stopping potential increase. Statement-2 is incorrect. Photoelectrons are emitted with a range of kinetic energies because different electrons have different binding energies.

3. Answer (2)

$P = nh\nu$

$4 \times 10^3 = 10^{20} \times 6.63 \times 10^{-34} \times \nu$

$\nu = \frac{4}{6.63} \times 10^{17}$ Hz. This is range of X-rays.

4. Answer (1)

As initial momentum is zero, so final momentum must also be zero.

$\therefore$ The two nuclei have equal and opposite momentum.

$\Rightarrow$ Same wavelength

5. Answer (2)

6. Answer (4)

When wavelength exceeds a certain wavelength, photoelectric effect ceases to exist.

7. Answer (2)

$$r = \frac{mv}{qB} = \frac{\sqrt{2meV}}{eB} = \frac{1}{B}\sqrt{\frac{2m}{e}V}$$

$$\Rightarrow V = \frac{B^2r^2e}{2m} = 0.8 \text{ V}$$

For transition between 3 to 2,

$$E = 13.6\left(\frac{1}{4} - \frac{1}{9}\right)$$

$$= \frac{13.6 \times 5}{36} = 1.88 \text{ eV}$$

Work function = 1.88 eV – 0.8 eV

= 1.08 eV = 1.1 eV

8. Answer (3)

Franck-Hertz exp.– Discrete energy level.

Photo-electric effect– Particle nature of light

Davison-Germer exp.– Diffraction of electron beam.

9. Answer (4)

$$\frac{hc}{\lambda} - \phi = \frac{1}{2}mv^2 \quad \text{...(i)}$$

$$4\frac{hc}{3\lambda} - \phi = \frac{1}{2}mv_1^2 \quad \text{...(ii)}$$

(ii) – $\frac{4}{3} \times$ (i) gives, $\frac{\phi}{3} = \frac{1}{2}mv^2 - \frac{1}{2}mv_1^2 \times \frac{4}{3}$

$$\Rightarrow V_1^2 > V^2 \times \frac{4}{3} \Rightarrow V_1 > \left(\frac{4}{3}\right)^{\frac{1}{2}} V$$

10. Answer (2)

$$v_1 = \frac{(m_1 - m_2)v}{m_1 + m_2} + 0 = \frac{v}{3}$$

$m_1 = m$

$m_2 = \frac{m}{2}$

$$\therefore p_1 = m.\left[\frac{v}{3}\right]$$

$$v_2 = \frac{2m_1v}{m_1 + m_2} + 0 = \frac{4v}{3}$$

$$p_2 = \frac{m}{2}\left[\frac{4v}{3}\right] = \frac{2mv}{3}$$

$\therefore$ de-Broglie wavelength $\frac{\lambda_A}{\lambda_B} = \frac{p_2}{p_1} = 2:1$

11. Answer (1)

$$\frac{1}{2}m(2v)^2 = \frac{hc}{350} - \phi_0$$

and, $\frac{1}{2}mv^2 = \frac{hc}{540} - \phi_0$

$$\Rightarrow \quad 4\left(\frac{hc}{540}\right) - \left(\frac{hc}{350}\right) = 3\phi_0$$

$\Rightarrow$ $9.12 - 3.54 = 3\phi_0$

$\Rightarrow$ $\phi_0 \simeq 1.8\,\text{eV}$

12. Answer (4)

Here $\lambda \simeq 7.5 \times 10^{-12}$ m

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

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

$$= \frac{(6.6\times10^{-34})^2 ev}{2\times9.1\times10^{-31}\times(7.5\times10^{-12})^2\times1.6\times10^{-19}}$$

$\simeq$ 25 keV

13. Answer (2)

$$\left(\frac{Nhc}{\lambda}\right)\frac{1}{\Delta t.\Delta A} = I$$

$$\Rightarrow \quad \left(\frac{N}{\Delta t}\right) = \frac{16\times10^{-3}\times1\times10^{-4}\times\lambda}{hc} \text{ (per sec)}$$

Given $\frac{hc}{\lambda}$ = 10 eV

So total incident photons per second

$$\Rightarrow \quad \frac{N}{\Delta t} = \frac{16\times10^{-7}}{10 \text{ eV}} = 9.98 \times 10^{11}$$

No. of emitted electrons per sec $= \frac{1}{10}\frac{N}{\Delta t}$

$= 9.98 \times 10^{10}$

$\approx 10^{11}$

Maximum kinetic energy = 10 eV – 5 eV = 5 eV

14. Answer (2)

$$\lambda_1 = \frac{10^{-3}\times3\times10^8}{6\times10^{14}} = 0.5\times10^{-9}$$

$$\lambda_1 = 5\times10^{-10} \text{ m}$$

$$v = \frac{h}{m\lambda_1} = \frac{6.6\times10^{-34}}{5\times10^{-10}\times9.1\times10^{-31}}$$

$= 1.45 \times 10^6$ m/s

15. Answer (1)

$h\nu = \phi + eV_0$

$$\frac{hc}{\lambda_1} = \phi + eV_1$$

$$\frac{hc}{\lambda_2} = \phi + eV_2$$

$$1240\left[\frac{1}{300} - \frac{1}{400}\right] = e(V_1 - V_2)$$

$(V_1 - V_2) \approx 1.0$ V

16. Answer (2)

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mqv}}$$

$$\frac{\lambda_A}{\lambda_B} = \frac{\left(\frac{h}{2mq\times50}\right)}{\left(\frac{h}{\sqrt{2\times4m\times q\times2500}}\right)} = \sqrt{200} = 14.41$$

17. Answer (1)

$2h\nu = 2\phi + eV_0$

$$\frac{h\nu}{2} = \phi + eV_0$$

$$\frac{3h\nu}{2} = \phi$$

$$\nu_0 = \frac{3\nu}{2}$$

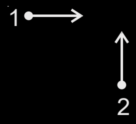
18. Answer (3)

Energy lost by electron = 5.6 – 0.7 = 4.9 eV

$$\frac{hc}{\lambda_{min}} = 4.9$$

$$\Rightarrow \lambda_{min} = \frac{1240}{4.9} = 250 \text{ nm}$$

19. Answer (4)



$$p_1 = \frac{h}{\lambda_1}$$

$$p_2 = \frac{h}{\lambda_2}$$

$$\therefore \quad p_f = \sqrt{p_1^2 + p_2^2}$$

$$\Rightarrow \quad \frac{h}{\lambda} = \sqrt{\frac{h^2}{\lambda_1^2} + \frac{h^2}{\lambda_2^2}}$$

$$\Rightarrow \quad \frac{1}{\lambda^2} = \frac{1}{\lambda_1^2} + \frac{1}{\lambda_2^2}$$

20. Answer (1)

$\lambda = 5 \times 10^{-7}$ m

$$\nu = \frac{3 \times 10^8}{5 \times 10^{-7}} = 6 \times 10^{14} \text{ Hz}$$

$$E = \frac{12375}{5000} = 2.475 \text{ eV}$$

$K_{max} = E - \phi = 0.48$ eV

21. Answer (1)

$\because \quad P = \frac{W}{c}$ and pressure = I/c

$\therefore \quad \frac{h}{\lambda} + \frac{h}{4\lambda} \Rightarrow \Delta P = \frac{5h}{4\lambda}$ for one photon

$$\therefore \quad \frac{5}{4} \cdot \frac{Nh}{\lambda \Delta t A} = \text{pressure}$$

$$\text{But } \left(\frac{Nhc}{\lambda \cdot \Delta t A}\right) = 50 \text{ W/m}^2$$

$$\therefore \quad \frac{5}{4} \times \frac{50}{c} = \text{pressure}$$

$$\therefore \quad F_n = \frac{5 \times 50 \times 1 \text{ m}^2}{4 \times c} = 20 \times 10^{-8} \text{ N}$$

22. Answer (1)

$$P_1 = \frac{h}{\lambda_x} \qquad P_2 = \frac{h}{\lambda_y}$$

$$P = P_1 - P_2 = h\left(\frac{1}{\lambda_x} - \frac{1}{\lambda_y}\right)$$

$$\therefore \quad P = \frac{h}{\lambda}$$

$$\frac{h}{\lambda} = h\left(\frac{1}{\lambda_x} - \frac{1}{\lambda_y}\right)$$

$$\frac{1}{\lambda} = \frac{|\lambda_y - \lambda_x|}{\lambda_x \lambda_y}$$

$$\lambda = \frac{\lambda_x \cdot \lambda_y}{|\lambda_x - \lambda_y|}$$

23. Answer (4)

Wavelength of incident wave (λ) = 260 nm

Cut off (threshold) wavelength (λ_0) = 380 nm

$$\text{Then} \quad KE_{max} = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$$

$$= 1237\left[\frac{1}{260} - \frac{1}{380}\right]$$

$$= \frac{1237 \times 120}{380 \times 260} = 1.5 \text{ eV}$$

24. Answer (4)

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

Let no. of photons per sec. is N

$$\Rightarrow \quad N\frac{hc}{\lambda} = 2 \text{ m}W$$

$$\Rightarrow \quad N = \frac{2 \times \lambda}{hC} = \frac{2 \times 5000 \times 10^{-3}}{12420 \times 1.6 \times 10^{-19}}$$

$N = 5 \times 10^{15}$

25. Answer (3)

$$P = \frac{\Delta E}{C}$$

$$= \frac{(25 \times 25) \times 40 \times 60}{3 \times 10^8} \text{ N-s}$$

$= 5 \times 10^{-3}$ N-s

26. Answer (4)

$$\phi = \frac{hc}{\lambda} = hv$$

$\therefore \quad \phi = h \times 4 \times 10^{14}$ Hz = 1.654 eV

$\Rightarrow \quad \phi \approx 1.66$ eV

27. Answer (4)

$$I = I_0 \cos^2 \theta$$

$$\Rightarrow \frac{I_0}{10} = I_0 \cos^2\theta$$

$$\Rightarrow \frac{1}{10} = \cos^2\theta$$

$$\Rightarrow \cos\theta = \frac{1}{\sqrt{10}} = 0.316$$

$$\Rightarrow \theta \approx 71.6°$$

$$\therefore \phi = 90 - \theta = 90 - 71.6 = 18.4°$$

28. Answer (1)

$$\lambda_e = \frac{h}{p_e} = \frac{h}{\sqrt{2mE}}$$

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

$$\Rightarrow \frac{\lambda_e}{\lambda_P} = \frac{1}{\sqrt{2mE}}\frac{E}{c} = \sqrt{\frac{E}{2m}}\cdot\frac{1}{c}$$

29. Answer (2)

de-Broglie wavelength (λ),

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

$$\therefore \lambda = \frac{h}{\sqrt{2m\,KE}}$$

$$\therefore \frac{\lambda_A}{\lambda_B} = \sqrt{\frac{K_B}{K_A}} = \sqrt{\frac{T_A - 1.5}{T_A}} \text{ (as given)}$$

Also, $\frac{\lambda_A}{\lambda_B} = \frac{1}{2}$

On solving $T_A = 2$ eV

$\therefore$ $K_B = T_A - 1.5 = 0.5$ eV

$\therefore$ Work function of metal B is

$\phi_B = E_B - K_B$

$= 4.5 - 0.5 = 4$ eV

For A, $\phi_A = E_A - T_A = 2$ eV

30. Answer (3)

Stopping potential (V) $\propto h^x I^y G^z C^r$

Here, h = plank's constant = $[ML^2T^{-1}]$

I = current = [A]

G = Gravitational constant = $[M^{-1}L^3T^{-2}]$

and c = speed of light = $[LT^{-1}]$

$\therefore$ and V = potential = $[ML^2T^{-3}A^{-1}]$

$\therefore$ $[ML^2T^{-3}A^{-1}] = [ML^2T^{-1}]^x [A]^y [M^{-1}L^3T^{-2}]^z [LT^{-1}]^r$

Comparing dimension of M, L, T, A, we get

y = –1, x = 0, z = – 1, r = 5

$$\therefore \boxed{v \propto h^0 I^{-1} G^{-1} c^5}$$

31. Answer (3)

$$v = v_0\hat{i} + v_0\hat{j} + \frac{eE_0}{m}t\,\hat{k}$$

$$\therefore |\vec{v}| = \sqrt{2v_0^2 + \left(\frac{eE_0t}{m}\right)^2}$$

Initialy, $\lambda_0 = \frac{h}{mv_0\sqrt{2}}$

Now, $\lambda = \frac{h}{m\sqrt{2v_0^2 + \left(\frac{eE_0t}{m}\right)^2}}$

$$\frac{\lambda}{\lambda_0} = \frac{1}{\sqrt{1 + \left(\frac{eE_0t}{\sqrt{2}mv_0}\right)^2}}$$

$$\lambda = \frac{\lambda_0}{\sqrt{1 + \frac{e^2E_0^2t^2}{2m^2v_0^2}}}$$

32. Answer (4)

$$\lambda = \frac{h}{\sqrt{2\,mk}}$$

if $\lambda' = \frac{\lambda}{2} \Rightarrow k' = 4k$

$$\Rightarrow \Delta E = 3E$$

33. Answer (2)

$$\phi = E_{ph} - (KE)_{\max}$$

$$p = \sqrt{2mk}$$

$$\Rightarrow k = \frac{p^2}{2m}$$

$$r = \frac{p}{eB}$$

$$\Rightarrow \quad k = \frac{r^2e^2B^2}{2m}$$

$$= \frac{12420}{6561} - \frac{r^2eB^2}{2m} \text{ (In eV)}$$

$$= 1.89 \text{ (eV)} - \frac{(10^{-4})(1.6\times10^{-19})\,9\times10^5}{2\times9.07\times10^{-31}}$$

$= (1.89 - 0.79)$ eV = 1.1 eV

34. Answer (2)

$$V = \frac{eE}{m}t$$

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

$$\frac{d\lambda}{dt} = \frac{-h}{eEt^2}$$

35. Answer (4)

$$\frac{\lambda_1}{\lambda_2} = \frac{m_2v_2}{m_1v_1}$$

$$m_1 = \frac{m_e}{5\times1.878\times10^{-4}}$$

$$= 9.7\times10^{-28}\text{ kg}$$

36. Answer (3)

$$K_1 = \frac{hc}{\lambda_1} - \phi_0$$

$$K_2 = \frac{hc}{\lambda_2} - \phi_0$$

$\because \quad K_2 = 3K_1$

$$\Rightarrow \quad 3\left[\frac{hc}{500} - \phi_0\right] = \frac{hc}{200} - \phi_0$$

$\Rightarrow \quad \phi_0 = 0.61$ eV

37. Answer (2)

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

$$P = (N)\frac{hc}{\lambda}$$

$$P_1 = P_2 \quad \Rightarrow \quad \frac{N_1}{\lambda_1} = \frac{N_2}{\lambda_2}$$

$$\Rightarrow \quad \frac{N_1}{N_2} = 500$$

38. Answer (2)

$$\lambda_0 = \frac{h}{\frac{m}{2}v_0}$$

$$\frac{m}{2}v_0 = \frac{m}{2}v_1 + \frac{m}{3}v_2$$

$v_0 = v_2 - v_1$

$$v_1 = \frac{v_0}{5}$$

$$\lambda_1 = \frac{h}{\frac{m}{2}\frac{v_0}{5}} = 5\,\lambda_0$$

$\Delta\lambda = 4\,\lambda_0$

39. Answer (2)

$$V = \frac{h}{e}f - \frac{\phi}{e}$$

Minimum energy for ejection = work function

ϕ = hf (for V = 0)

$$= \frac{6.62\times10^{-34}\times5.5\times10^{14}}{1.6\times10^{-19}}$$

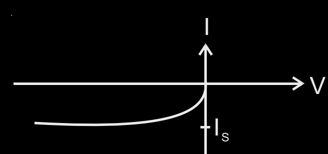
= 2.27 eV

40. Answer (2)

There will be no effect on graph.

41. Answer (3)

In photodiode, photocurrent increases with increasing biasing voltage and then becomes saturated.



42. Answer (3)

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

$$p = \sqrt{2mk}$$

$$\lambda \propto \frac{1}{\sqrt{m}}$$

43. Answer (1)

$$V_{rms} = \sqrt{\frac{3KT}{m}}$$

$$\lambda = \frac{h}{\sqrt{3KTm}}$$

44. Answer (9)

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

$$\frac{hc}{3\lambda} - \phi = \frac{eV}{4} \qquad ....(ii)$$

From (i) and (ii) $\frac{hc}{3\lambda} - \phi = \frac{hc}{4\lambda} - \frac{\phi}{4}$

$$\Rightarrow \frac{hc}{\lambda}\left(\frac{1}{3} - \frac{1}{4}\right) = \frac{3\phi}{4}$$

$\Rightarrow \frac{hc}{\lambda}\frac{1}{9} = \phi$ Now if $\phi = \frac{hc}{\lambda_0}$

$\therefore \lambda_0 = 9\lambda$ So, $n = 9$

45. Answer (02.00)

$$\frac{1}{2}mv^2 = \frac{hc}{\lambda} - \phi$$

$$\frac{1}{2}mv_1^2 = 4 - \phi \qquad ...(i)$$

$$\frac{1}{2}mv_2^2 = 2.5 - \phi \qquad ...(ii)$$

Given $\frac{v_1}{v_2} = 2$

$$\Rightarrow 4 = \frac{4-\phi}{2.5-\phi} \Rightarrow \phi = 2 \text{ eV}$$

46. Answer (1)

$$E = \frac{hc}{\lambda}, P = \frac{h}{\lambda}$$

on decreasing wavelength of photon, energy will decrease

47. Answer (3)

$$\lambda_p = \frac{h}{m_p \times v_p}$$

$$\lambda_\alpha = \frac{h}{m_\alpha \times v_\alpha}$$

$$\because \lambda_p = \lambda_\alpha \Rightarrow m_p v_p = m_\alpha v_\alpha$$

$$\Rightarrow \frac{v_p}{v_\alpha} = \frac{m_\alpha}{m_p} = \frac{4}{1}$$

48. Answer (2)

$$\lambda_P = \frac{h}{\sqrt{2m_p \times (e \times V)}}$$

$$\lambda_\alpha = \frac{h}{\sqrt{2m_\alpha \times (2e \times V)}}$$

$$\therefore \frac{\lambda_P}{\lambda_\alpha} = \sqrt{\frac{m_\alpha}{m_P} \times 2} = \sqrt{4 \times 2}$$

$$= 2\sqrt{2} = 2.8$$

49. Answer (4)

$$\lambda_e = \frac{h}{m_e \times v}$$

$$\lambda_p = \frac{h}{m_p \times v}$$

$$\Rightarrow \frac{\lambda_e}{\lambda_p} = \frac{m_p}{m_e} = 1836$$

50. Answer (3)

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

$$\frac{hc}{\lambda_1} - eV_1 = \frac{hc}{\lambda_2} - eV_2$$

$$\frac{1240}{491} - 0.71 = \frac{1240}{\lambda_2} - 1.43$$

$$\frac{1240}{\lambda_2} = \frac{1240}{491} + 0.72$$

$\lambda_2 = 382$ nm

51. Answer (01.00)

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

$$\Rightarrow V^2 = \frac{2}{m}(E-\phi)$$

$$\Rightarrow V_1^2 = \frac{2}{m}(\phi) \quad ...(1)$$

$$V_2^2 = \frac{2}{m}(9\phi) \quad ...(2)$$

From (1) & (2),

$$\frac{V_1}{V_2} = \frac{1}{3}$$

$$\Rightarrow \frac{x}{3} = \frac{1}{3}$$

$\Rightarrow$ (x = 01.00)

52. Answer (3)

$\because \; eV_0 = h\nu - \phi$

$\therefore$ Stopping potential is dependent on frequency.

53. Answer (4)

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

$$p = \sqrt{2mk}$$

Kinetic energy of both are same.

$$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{m_p}{m_e}} = \sqrt{\frac{1.00727}{0.00055}}$$

54. Answer (3)

$$\lambda_1 = \frac{h}{\sqrt{2mE}}$$

$$\lambda_2 = \frac{hc}{E}$$

$$\frac{\lambda_1}{\lambda_2} = \frac{1}{c}\sqrt{\frac{E}{2m}}$$

55. Answer (4)

$$hf_1 = \phi + \frac{1}{2}mv_1^2$$

$$hf_2 = \phi + \frac{1}{2}mv_2^2$$

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

56. Answer (4)

$v_{particle} = 4v_{electron}$

$\lambda_{particle} = 2\,\lambda_{electron} \Rightarrow p_{particle} = \frac{1}{2}p_{electron}$

$$\therefore \; m_{particle}\,v_{particle} = \frac{m_{electron}v_{electron}}{2}$$

$$\Rightarrow m_{particle} = \frac{m_{electron}}{8}$$

57. Answer (4)

$$R.P \propto \frac{1}{\lambda},\; \lambda \propto \frac{1}{p}$$

58. Answer (3)

$$\text{Energy of photon} = 13.6\left[\frac{1}{4} - \frac{1}{9}\right]$$

$$= 1.89 \text{ eV}$$

$$r = \frac{mv}{qB}$$

$$\text{K.E} = \frac{r^2q^2B^2}{2m} = \frac{49\times10^{-6}\times1.6\times10^{-19}\times25\times10^{-8}}{2\times9.1\times10^{-31}}\text{eV}$$

K.E = 1.08 eV

ϕ = 1.89 – 1.08 = 0.81 eV

59. Answer (4)

$$e\,3V_0 = \frac{hc}{\lambda} - \frac{hc}{\lambda_0} \quad ...(i)$$

$$eV_0 = \frac{hc}{2\lambda} - \frac{hc}{\lambda_0} \quad ...(ii)$$

$\Rightarrow \lambda_0 = 4\lambda$

60. Answer (4)

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2km}}$$

$$\frac{\lambda_e}{\lambda_p} = \sqrt{\frac{k_pm_p}{k_em_e}} = \sqrt{\frac{m_p}{m_e}}$$

61. Answer (3)

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

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

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

$$\Rightarrow \lambda_e > \lambda_p > \lambda_\alpha$$

62. Answer (3)

$P_1 = P_2$

$$\lambda_1 = \frac{h}{P_1},\ \lambda_2 = \frac{h}{P_2}$$

So $\lambda_1 : \lambda_2 = 1 : 1$

63. Answer (2)

$$\frac{hc}{\lambda} = \frac{hc}{\lambda_0} + 4.8e \quad \text{... (i)}$$

$$\frac{hc}{2\lambda} = \frac{hc}{\lambda_0} + 1.6e \quad \text{... (ii)}$$

Eq. (i) ÷ eq. (ii),

$$\Rightarrow 2 = \frac{\frac{hc}{\lambda_0} + 4.8e}{\frac{hc}{\lambda_0} + 1.6e}$$

$$\Rightarrow \frac{hc}{\lambda_0} = 1.6e \Rightarrow \lambda_0 = 4\lambda$$

64. Answer (2)

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

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

Also, $k_{ph} = \dfrac{hc}{\lambda}$

$$\Rightarrow \quad \frac{k_e}{k_{ph}} = \frac{h^2}{2m\lambda^2} \times \frac{\lambda}{hc}$$

$$\text{ratio} = \frac{h}{2m\lambda c} = \frac{h}{2mc \times \frac{h}{mv}}$$

$$= \frac{v}{2c}$$

65. Answer (125)

$$R = \frac{\sqrt{2m(\text{KE})}}{qB} \text{ where KE} = \frac{hc}{\lambda} - 2\times10^{-19}$$

$$\Rightarrow \quad R = \frac{\sqrt{2\times9\times10^{-31}\times2\times10^{-19}}}{1.6\times10^{-19}\times B}$$

$$B = \frac{6\times10^{-25}}{0.3\times1.6\times10^{-19}} = 125\times10^{-7}\,\text{T}$$

66. Answer (910)

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

$$\Rightarrow \quad \lambda_2 = \frac{\lambda_1 p_1}{p_2} = \frac{9.1\times10^{-31}\times10^6}{10^{-27}}\lambda_1$$

$$= 910\lambda_1$$

67. Answer (3)

$$\phi_0 = 3.1\ \text{eV}$$

$$E_1 = \frac{-13.6}{9}\ \text{eV}$$

$$\therefore \quad E_{\text{photon}} = \left(3.0 + \frac{13.6}{9}\right)\text{eV} = 4.511$$

$\therefore$ KE of photoelectron = 4.511 – 3.1 = 1.41 eV

68. Answer (4)

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

$$\Rightarrow e(V_1 - V_2) = (hc)\left[\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right]$$

$\Rightarrow e(V_1 - V_2) = 1.33$ eV

69. Answer (354)

$E_0 = 200$

$$I = \frac{1}{2}\varepsilon_0 E_0^2 C$$

$$P = \frac{2I}{C} = \varepsilon_0 E_0^2 = 8.85\times10^{-12}\times4\times10^4$$

$$= 35.4\times10^{-8} = \frac{354}{10^9}\ \text{N/m}^2$$

70. Answer (1)

$$\lambda = \frac{h}{P} = \frac{h}{\sqrt{2Em}}$$

Now, $\lambda_2 = \frac{h}{\sqrt{2E_2m}}$

$$\frac{3}{4}\lambda = \frac{h}{\sqrt{2E_2m}}$$

$$\Rightarrow \frac{3}{4}\frac{h}{\sqrt{2Em}} = \frac{h}{\sqrt{2E_2m}}$$

$$\frac{9}{16}\frac{1}{E} = \frac{1}{E_2}$$

$$E_2 = \frac{16}{9}E$$

So, $E_2 - E = \frac{16}{9}E - E = \frac{7}{9}E$

71. Answer (4)

Intensity change does not affect the maximum kinetic energy of emitted electron.

72. Answer (2)

$$\frac{hc}{\lambda_1} = \phi + eV_1$$

$$\frac{hc}{\lambda_2} = \phi + eV_2$$

$$\frac{hc}{\lambda_2} - \frac{hc}{\lambda_1} = e(V_2 - V_1)$$

$$V_2 = \frac{hc}{e}\left[\frac{1}{\lambda_2} - \frac{1}{\lambda_1}\right] + V_1$$

V_2 = 1.25 V

73. Answer (3)

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

As $\lambda_P = \lambda_e \Rightarrow P_P = P_e$

But $P = \sqrt{2mK}$

$$\Rightarrow K = \frac{P^2}{2M} \Rightarrow K \propto \frac{1}{M}(\text{for same } P)$$

$\Rightarrow K_P < K_e$

74. Answer (2)

$$\lambda = \frac{h}{\sqrt{2m(\text{K.E.})}}$$

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

$$= \frac{6.6 \times 10^{-34}}{\sqrt{9 \times 10^{-31} \times 3 \times 1.38 \times 10^{-23} \times 300}}$$

$= 0.624 \times 10^{-8} = 6.24$ nm

75. Answer (2)

Let us say the work function is ϕ

$$\Rightarrow 2\phi = \phi + \frac{1}{2}mv_1^2 \quad \text{... (1)}$$

and $5\phi = \phi + \frac{1}{2}mv_2^2$ ... (2)

From (1) and (2)

$$\frac{v_2^2}{v_1^2} = \frac{4}{1} \text{ or } \frac{v_2}{v_1} = 2$$

76. Answer (1)

Davisson-Germer experiment is done and establishes the wave nature of electrons. Interference and diffraction establishes wave nature.

77. Answer (2)

de Broglie wavelength $\lambda = \frac{h}{p}$

$$\Rightarrow \lambda = \frac{h}{\sqrt{2mK}}$$

Where K: kinetic energy

$\Rightarrow$ For some K, $\lambda \propto \frac{1}{\sqrt{m}}$

Since $m_\alpha > m_n > m_p > m_e$

$\Rightarrow \lambda_\alpha < \lambda_n < \lambda_p < \lambda_e$

78. Answer (2)

$$\lambda_e = \lambda_{ph} \Rightarrow \frac{h}{p_e} = \frac{hc}{E_{ph}}$$

$$\Rightarrow E_{ph} = p_e \times c = 2E_e\frac{c}{\upsilon}$$

$$\Rightarrow \frac{E_e}{E_{ph}} = \frac{\upsilon}{2c}$$

79. Answer (2)

$K_\alpha = K_C$

$$\frac{p_\alpha^2}{2m_\alpha} = \frac{p_C^2}{2m_C}$$

$$\frac{p_\alpha}{p_C} = \sqrt{\frac{m_\alpha}{m_C}}$$

$$\text{So } \frac{\lambda_\alpha}{\lambda_C} = \frac{h/p_\alpha}{h/p_C} = \sqrt{\frac{m_C}{m_\alpha}}$$

$$\text{So } \frac{\lambda_\alpha}{\lambda_C} = \sqrt{3}$$

80. Answer (1)

$$\lambda_p = \frac{h}{p} = \frac{hc}{E} \qquad \ldots(i)$$

$$\lambda_e = \frac{h}{\sqrt{2mE}} \qquad \ldots(ii)$$

From (i) and (ii)

$\lambda_p \propto \lambda_e^2$

$\Rightarrow$ Option 1 is correct

81. Answer (2)

$$K_1 = \frac{hc}{\lambda_1} - \phi = \frac{hc}{3\lambda_2} - \phi \qquad \ldots(i)$$

$$\text{and } K_2 = \frac{hc}{\lambda_2} - \phi \qquad \ldots(ii)$$

from (i) and (ii) we can say

$3K_1 = K_2 - 2\phi$

$$K_1 < \frac{K_2}{3}$$

82. Answer (2)

When energy of incident radiation is equal to the work function of the metal, then the KE of photoelectrons would be zero. But this statement does not comment on the situation when energy is less than the work function.

83. Answer (4)

Frequency of EM waves

$$= \frac{6}{2\pi} \times 10^{15} \text{ and } \frac{9}{2\pi} \times 10^{15}$$

Energy of one photon of these waves

$$= \left(4.14 \times 10^{-15} \times \frac{6}{2\pi} \times 10^{15}\right) \text{ eV}$$

$$\text{and } \left(4.14 \times 10^{-15} \times \frac{9}{2\pi} \times 10^{15}\right) \text{ eV}$$

$= 3.95$ eV and 5.93 eV

$\Rightarrow$ Energy of maximum energetic electrons

$= 5.93 - 2.50 = 3.43$ eV

84. Answer (3)

$$\because \quad K_m = \frac{hc}{\lambda} - \phi$$

$$\Rightarrow \quad K = \frac{1230}{800} - \phi$$

$$\text{and, } 2K = \frac{1230}{500} - \phi$$

$$\Rightarrow \quad 2 \times \frac{1230}{800} - 2\phi = \frac{1230}{500} - \phi$$

$\Rightarrow \phi = 0.615$ eV

85. Answer (4)

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

$$\text{so } \frac{\lambda_p}{\lambda_d} = \frac{\sqrt{m_d V_d}}{\sqrt{m_p V_p}} = \frac{1}{\sqrt{2}}$$

$$\frac{2V_d}{V_p} = \frac{1}{2}$$

$$\frac{V_p}{V_d} = \frac{4}{1}$$

86. Answer (2)

$\lambda = 900$ nm

$I = 100$ W/m^2

$A = 10^{-4}$

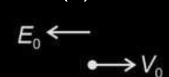
$\Rightarrow P = 10^{-2}$ W

$\Rightarrow$ Number of photons incident per second

$$= \frac{10^{-2}\lambda}{hc}$$

$$= \frac{9 \times 10^{-11} \times 10^2}{6.63 \times 10^{-34} \times 3 \times 10^8} \simeq 4.5 \times 10^{16}$$

87. Answer (4)



$$\therefore \quad a_x = \frac{eE_0}{m}\hat{i}$$

$$\therefore \quad v(t) = V_0 + \frac{eE_0}{m}t$$

$$\therefore \quad \frac{\lambda_0}{\lambda_2} = \frac{mv}{mV_0} = \left(1+\frac{eE_0 t}{mV_0}\right)$$

$$\Rightarrow \quad \lambda_2 = \frac{\lambda_0}{\left(1+\frac{eE_0 t}{mV_0}\right)}$$

88. Answer (2)

$$\because \quad \frac{1}{2}mv_m^2 = h\nu - \phi$$

$\Rightarrow v_m^2$ varies linearly with frequency.

And, threshold wavelength can be explained by particle nature of light.

89. Answer (4)

$$\text{Pressure} = \frac{I}{c}$$

$$\Rightarrow \quad \frac{F}{A} = \frac{I}{c}$$

$$\Rightarrow \quad I = \frac{7.2\times10^{-9}\times3\times10^{8}}{36\times10^{-4}}\ \text{W/m}^2$$

$$= 600\ \text{W/m}^2$$

$$\Rightarrow \quad I = 0.06\ \text{W/cm}^2$$

90. Answer (3)

$$\frac{1}{2}mv_1^2 = 5\phi - \phi$$

$$\text{And, } \frac{1}{2}mv_2^2 = 10\phi - \phi$$

$$\Rightarrow \left(\frac{v_1}{v_2}\right)^2 = \frac{4}{9}$$

$$\Rightarrow \frac{v_1}{v_2} = \frac{2}{3}$$

91. Answer (2)

$$k = \frac{hc}{\lambda} - \phi = E$$

$$\text{and, } 2k = \frac{hc}{\lambda_2} - \phi = 2E$$

$$\Rightarrow \quad \frac{hc}{\lambda} - E = \frac{hc}{\lambda_2} - 2E$$

$$\Rightarrow \quad \frac{hc}{\lambda_2} = \frac{hc}{\lambda} + E$$

$$\Rightarrow \quad \lambda_2 = \frac{hc\lambda}{hc + \lambda E}$$

92. Answer (3)

Linear momentum is conserved

so $p_{M'/3} = p_{2M'/3}$

so $\dfrac{\lambda_{M'/3}}{\lambda_{2M'/3}} = \dfrac{1}{1}$

93. Answer (1)

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

$$R = \frac{mv}{Bq} = \frac{\sqrt{2m(KE)}}{Bq} \quad \text{...(ii)}$$

Putting the values,

$\phi \simeq 1.36$ eV

94. Answer (2)

$$3.8 = 0.6 + \frac{1}{2}mv_1^2$$

$$1.4 = 0.6 + \frac{1}{2}mv_2^2$$

$$\Rightarrow \quad \frac{v_1^2}{v_2^2} = \frac{3.2}{0.8} = \frac{4}{1}$$

$$\Rightarrow \quad \frac{v_1}{v_2} = \frac{2}{1}$$

95. Answer (35)

$$\frac{hc}{\lambda} - \phi = KE = eV_0$$

$$\Rightarrow \frac{6.63\times10^{-34}\times3\times10^{8}}{6630\times10^{-10}} - 6.63\times10^{-34} f_{th}$$

$$= 1.6\times10^{-19}\times0.4$$

$$\Rightarrow f_{th} \simeq 35.11 \times 10^{13}\ \text{H}$$

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