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) $\frac{\lambda}{5}$

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]**

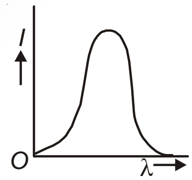
(1) Statement 1 is true, Statement 2 is false

(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)


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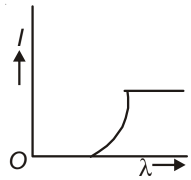

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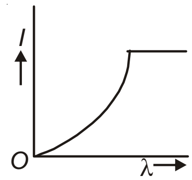

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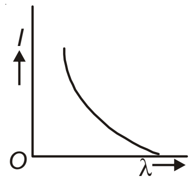


7. The radiation corresponding to $3 \rightarrow 2$ transition of hydrogen atoms falls on a metal surface to produce photoelectrons. These electrons are made to enter a magnetic field of 3×10^{-4} T. If the radius of the largest circular path followed by these electrons is 10.0 mm, the work function 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) $2\ \nu$

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}

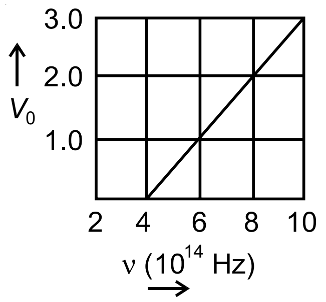
25. Light is incident normally on a completely absorbing surface with an energy flux of 25 Wcm^{-2}. If the surface has an area of 25 cm^2, the momentum transferred to the surface in 40 min time duration will be **[JEE (Main)-2019]**

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

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

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

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) $\dfrac{1}{250}$ (2) $\dfrac{1}{500}$
(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]**

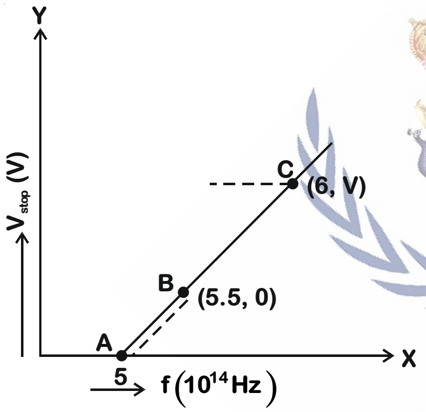
(1) $\Delta\lambda = 2\lambda_0$ (2) $\Delta\lambda = 4\lambda_0$

(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)

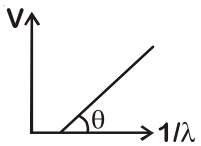
[JEE (Main)-2020]



(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]

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