Ravi Maths Tuition

Dual Nature of Radiation and Matter

12th Standard

Physics

Multiple Choice Question 146 x 1 = 146

1) The wavelength of a photon needed to remove a proton from a nucleus which is bound to the nucleus with 1 MeV energy is nearly

(a) 1.2 nm (b) 1.2x10^{-3} nm (c) 1.2x10^{-6} nm (d) 1.2x10^{1} nm

2) Consider a beam of electrons (each electron with energy E_0) incident on metal surface kept in an evacuated chamber. Then

(a) no electrons will be emitted as only photons can emit electrons.

(b) electrons can be emitted but all with an energy, E_0 .

(c) electrons can be emitted with any energy,with a maximum of E_0 $-\phi(\phi$ is the work function).

(d) electrons can be emitted with any energy, with a maximum of E_0

3) A proton,a neutron, an electron and an α -particle have the same energy.Then their de-Broglie wavelengths compare as

(a) $\lambda_p = \lambda_n > \lambda_c > \lambda_\alpha$ (b) $\lambda_\alpha < \lambda_= \lambda_n > \lambda_c$ (c) $\lambda_e < \lambda_= \lambda_n > \lambda_\alpha$

(d) $\lambda_c = \lambda = \lambda_n = \lambda_\alpha$

4) An electron is moving with an initial velocity $\frac{h}{mv} = v_0 \hat{L}$ and is in a magnetic field $\overrightarrow{B} = B_0 \vec{j}$ Then its de-Broglie wavelength

(a) remains constant (b) increases with time. (c) decreases with time.

(d) increases and decreases periodically.

5) An electron (mass m) with an initial velocity $v = v_0 \vec{i} (v_0 > 0)$ is an electric field $v = v_0 \vec{i} (v_0 > 0)$ its de-Broglie wave-length at time t is given by

(a) $\frac{\lambda_0}{\left(1+\frac{eE_0}{m}\frac{t}{v_0}\right)}$ (b) $\lambda\left(1+\frac{eE_0 t}{mv_0}\right)$ (c) λ_0 (d) $\lambda_0 t.$

6) An electron (mass m) with an initial velocity $v = v_0 \vec{i}$ is in an electric field $E = E_0 \vec{j} E = E_0 \vec{j}$. If $\lambda = \frac{h}{mv_0}$ its de-Broglie wavelength at time t is given by

(a) λ_0 (b) $\lambda_0 \sqrt{1+\frac{e^2 E_0^2 \quad t^2}{m^2 v_0^2}}$ (c) $\frac{\lambda_0}{\sqrt{1+\frac{e^2 E^2 t^2}{m^2 v_0^2}}}$ (d) $\frac{\lambda_0}{\sqrt{1+\frac{e^2 E^2 t^2}{m^2 v_0^2}}}$

7) Relativistic corrections become necessary when the expression for the kinetic energy $\frac{1}{2}mv^2$ becomes comparable with mc^2 where m is the mass of the particle. At what de-Broglie wavelength will relativistic corrections become important for an electron?

(a) $\lambda = 10nm$ (b) $\lambda = 10^{-1}nm$ (c) $\lambda = 10^{-4}nm$ (d) $\lambda = 10^{-6}nm$

8) The de-Broglie wavelength of a photon is twice the de-Broglie wavelength of an electron.The speed of the electron is $v_e = \frac{c}{100}$ Then

(a) $\frac{E_e}{E_p} = 10^{-4}$ (b) $\frac{E_e}{E_p} = 10^{-2}$ (c) $\frac{p_e}{m_e c} = 10^{-2}$ (d) $\frac{p_e}{m_e c} = 10^{-4}$

9) Two particles $A_1 and A_2$ of masses $m_1, m_2 (m_1 > m_2)$ have the same de-Broglie wavelength. Then

(a) their momenta are the same. (b) their energies are the same.

(c) energy of A_1 is less than the energy of A_2 . (d) energy of A_1 is more than the energy of A_2 .

10) Photons absorbed in matter are converted to heat.A source emitting n photon/sec frequency v is used to convert 1 kg of ice at 0^0c . Then the time t taken for the conversation.

(a) decreases with increasing n, with v fixed. (b) decreases with n fixed, v increasing

(c) remains constant with n and v changing such that nv = constant

(d) increases when the product nv increases.

11) The photoelectric effect can be explained on the basis of

(a) Corpuscular theory (b) Wave theory (c) Electromagnetic theory (d) quantum theory

12) Which of the following has minimum stopping potential?

(a) Blue (b) Yellow (c) Violet (d) Red

13) When radiation is incident on a photoelectron emitter, the stopping potential is found to be 9V.If e/m for the electron is $1.8 \times 10^{11} C/kg$ the maximum velocity of the ejected electron is

(a) $6 \times 10^5 m/s$ (b) $8 \times 10^5 m/s$ (c) $10^6 ms^{-1}$ (d) $1.8 \times 10^6 m/s$

14) Two photons, each of energy 2.5eV are simultaneously incident on the metal surface. If the work function of the metal is 4.5eV, then from the surface of metal

(a) one electron will be emitted with energy 0.5eV (b) two electrons will be emitted with energy 0.25eV

(c) more than two electrons will be emitted (d) not a single electron will be emitted.

15) The maximum velocity of an electron emitted by light of wavelength λ incident on the surface of a metal of wor4k function ϕ is[h = Plank's constant, c = speed of light and m = mass of electron]

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

16) The photoelectric work function for a metal surface is 4.125eV. The cutoff wavelength for this surface is

(a) $4125\mathring{A}$ (b) $2062.5\mathring{A}$ (c) $3000\mathring{A}$ (d) $6000\mathring{A}$

17) The slope of frequency of incident light and stopping potential for a given surface will be

(a) h (b) h/e (c) eh (d) e

18) The threshold wavelength for a metal having work function $\phi_0\ is\ \lambda_0$. What is the threshold wavelength for a metal whose work function is $\phi_0/2$

(a) $4\lambda_0$ (b) $2\lambda_0$ (c) $\lambda_0/2$ (d) $\lambda_0/4$

19) The work function for metals A,B and C are respectively 1.92eV, 2.0eV and 5.0eV. According to Einstein's equation, the metals which will emit photoelectrons for radiation of wavelength $4100\mathring{A}$ is/are

(a) none (b) A only (c) A and B only (d) B and C only

20) The wavelength of matter wave is independent of

(a) mass (b) velocity (c) momentum (d) charge

21) If E1, E_2, E_3 and E_4 are the respective kinetic energies of electron, deutron, proton and neutron having same de-Broglie wavelength. Select the correct order in which those values would increase.

(a) E_1, E_3, E_4, E_2 (b) E_2, E_4, E_3, E_1 (c) E_2, E_4, E_1, E_3 (d) E_3, E_1, E_2, E_4

22) What is de-Broglie wavelength associated with electron moving under a potential difference of 10^4 V.

(a) 12.27nm (b) 1 nm (c) 0.01227nm (d) 0.1227nm

23) A particle is dropped from a height H. The de Broglie wavelength of the particle as a function of height is proportional to

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

24) The wavelength of a photon needed to remove a proton from a nucleus which is bound to the nucleus with 1 MeV energy is nearly,

(a) $1.2nm$ (b) $1.2 \times 10^{-3}nm$ (c) $1.2 \times 10^{-6}nm$ (d) $1.2 \times 10^{1}nm$

25) Consider a beam of electrons (each with energy E_0) incident on a metal surface kept in an evacuated chamber. Then

(a) no electrons will be emitted as only photons can emit electrons

(b) electrons can be emitted but all with an energy E_0

(c) electrons can be emitted with any energy, with a maximum of $E_0 - \phi$ (ϕ is the work function)

(d) electrons can be emitted with any energy, with a maximum of E_0

26) An electron is moving with an initial velocity $\vec{v} = v_0\hat{i}$ and is in a magnetic field $\vec{B} = B_0\hat{j}$. Then it's de Broglie wavelength

(a) remains constant (b) increases with time (c) decreases with time

(d) increases and decreases periodically

27) Two particles A_1 and A_2 masses m_1, m_2 ($m_1 > m_2$) have the same de Broglie wavelength. Then

(a) their momenta are their same (b) their energies are their same

(c) energy of A_1 is less than the energy of A_2 (d) energy of A_1 is more than the energy of A_2

28) When a metallic is illuminated with radiation of wavelength λ , the stopping potential is V.If the same surface is illuminated with radiation of wavelength, 2λ the stopping potential is V/4. The threshold wavelength for the metallic surface is

(a) 4λ (b) 5λ (c) $5\lambda/2$ (d) 3λ

29) A photoelectric surface is illuminated successively by monochromatic light of wavelength λ and $\lambda/2$ if the maximum kinetic energy of the emitted photoelectrons in the second case is 3 times that of first case, the work function of the material is (h = plank's constant c = speed of light)

(a) $\frac{hc}{3\lambda}$ (b) $\frac{hc}{2\lambda}$ (c) $\frac{hc}{\lambda}$ (d) $\frac{2hc}{\lambda}$

30) If K_1 and K_2 are maximum kinetic energies of photoelectrons emitted when light of wavelength λ_1 and λ_2 respectively are incident on a metallic surface.If $\lambda_1 = 3\lambda_2$

(a) $K_1 > \left(\frac{K_2}{3}\right)$ (b) $K_1 < \left(\frac{K_2}{3}\right)$ (c) $K_1 = 3K_2$ (d) $K_2 = 3K_1$

31) According to Einstein's photoelectric equation, the plot of the kinetic energy of the emitted photoelectrons from a metal verses the frequency of the incident radiation gives a straight line whose slope.

(a) depends on the nature of the metal used (b) depends on the intensity of the radiation

(c) depends both on the intensity of the radiation and the metal used

(d) is the same for all metals and independent of the radiation.

32) A and B are two metals with threshold frequencies $1.8 \times 10^{14}Hz$ and $2.2 \times 10^{14}Hz$ Two identical photons of energy 0.825 eV each are incident on them. Then photoelectrons are emitted in (take $h = 6.63 \times 10^{-34}J/s$

(a) B alone (b) A alone (c) neither A nor B (d) both A and B

33) In a photoemissive cell, with exciting wavelength λ the fastest electron has speed v. If the exciting wavelength is changed to $\frac{3\lambda}{4}$, the speed of the fastest electron will be

(a) $v\left(\frac{3}{4}\right)^{1/2}$ (b) $v\left(\frac{4}{3}\right)^{1/2}$ (c) $lessthan\ v\left(\frac{3}{4}\right)^{1/2}$ (d) $greaterthan\ v\left(\frac{3}{4}\right)^{1/2}$

34) The collector plate in an experiment on photo-electric effect is kept vertically above the emitter plate. Light source is put on and a saturation photoelectric current is recorded. An electric field is switched on which has a vertically downward direction

(a) the stopping potential will decrease (b) the threshold wavelength will increase

(c) the photoelectric current will increase (d) the kinetic energy of the electrons will increase

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

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

36) The kinetic energy of an electron is E.When the incident light has wavelength λ To increase the kinetic energy to 2E, the incident light must have wavelength.

(a) $\frac{hc}{E\lambda - hc}$ (b) $\frac{h\lambda}{E\lambda + hc}$ (c) $\frac{hc\lambda}{E\lambda + hc}$ (d) $\frac{hc\lambda}{E\lambda - hc}$

37) When light of wavelength 400nm is incident on the cathode of a potential is 6V. If the wavelength of incident light is increased by 600nm, the new value of stopping potential is: [use hc = 1240 eVnm]

(a) 4.97V (b) 4.76V (c) 4.56V (d) 4.14V

38) A photosensitive metallic surface has work function hv_0. If photons of energy $3hv_0$ falls on this surface. The electrons come out with a maximum velocity of $5 \times 10^6 m/s$. When the photon energy is increased to $9v_0$. The maximum velocity of photoelectron will be:

(a) $8 \times 10^5 m/s$ (b) $10^9 m/s$ (c) $10^8 m/s$ (d) $10^7 m/s$

39) If the elctron frequency of light in a photoelectric experiment is doubled the stopping potential will

(a) be doubled (b) be halved (c) become more than double (d) become less than double

40) Maximum velocity of photoelectrons emitted by a metal surface is $1.2 \times 10^6 m/s$. Assuming the specific charge of the electron to be $1.8 \times 10^{11} C/kg$ the value of stopping potential in volt will be:

(a) 2 (b) 3 (c) 4 (d) 6

41) The velocity of the most energetic electrons emitted from a metallic surface is doubled when the frequency v of incident radiation is double.The work function of this metal is

(a) zero (b) hv/3 (c) hv/2 (d) 2hv/3

42) Light wavelength λ strikes a photosensitive surface and electrons are ejected with kinetic energy E. If the kinetic energy is to be increased to 2E, the wavelength must be changed to λ' where

(a) $\lambda' = \frac{\lambda}{2}$ (b) $\lambda' = 2\lambda$ (c) $\lambda' > \lambda$ (d) $\frac{\lambda}{2} < \lambda' < \lambda$

43) Monochromatic light of frequency f_1 incident on a photocell and the stopping potential is found to be V_1. What is the new stopping potential of the cell if it radiated by monochromatic light of frequency f_2?

(a) $V_1 - \frac{h}{e}(f_2 - f_1)$ (b) $V_1 + \frac{h}{e}(f_2 + f_1)$ (c) $V_1 - \frac{h}{e}(f_2 + f_1)$
(d) $V_1 + \frac{h}{e}(f_2 - f_1)$

44) The threshold frequency for a certain metal is v_0 When light of frequency $2v_0$ is incident on it, the maximum velocity of photoelectrons is $4 \times 10^6 ms^{-1}$. If the frequency of incident radiation is increased by $3v_0$ then the maximum velocity of photoelectrons in ms^{-1} will be

(a) $(4/5) \times 10^6$ (b) 2×10^6 (c) 4×10^6 (d) 8×10^6

45) Silver has a work function of 4.7eV when ultraviolet light of wavelength 100 nm is incident upon it, a potential 0f 7.7 is required to stop the photoelectrons from reaching the collector plate.How much potential will be required to stop the photoelectrons when light of wavelength 200 nm is incident upon silver?

(a) 3.85V (b) 1.93V (c) 1.50V (d) 3.0V

46) In a photoelectric effect experiment, the maximum kinetic energy of the emitted electron is 1eV for incoming radiation of frequency v_0 and 3eV for incoming radiation of frequency $3v_0/2$. What is the maximum kinetic energy of electrons emitted fro incoming radiation of frequency $9v_0/4$?

(a) 3 eV (b) 4.5 eV (c) 6 eV (d) 9 eV

47) The work function of a photosensitive material is 6.2 eV.The wavelength of the incident radiation for which the stopping potential is 5 V lies in the

(a) infrared region (b) X-ray region (c) ultraviolet region (d) visible region

48) Given that light of wavelength 10,000 $\overset{\circ}{A}$ has an energy equal to 1.23eV. When light of wavelength 5000$\overset{\circ}{A}$ and intensity I_0 falls on a photosensitive plate of photocell, the saturation current is $0.43 \times 10^{-6} A$ and the stopping potential is 1.36V Then the work function is

(a) 0.43eV (b) 1.10eV (c) 1.36eV (d) 2.72eV

49) When the energy of the incident radiation is increased by 20%, the kinetic energy of the photoelectrons emitted from a metal surface increased from 0.5eV to 0.8eV. Then work function of the metal is

(a) 0.65eV (b) 1.0eV (c) 1.3eV (d) 1.5eV

50) The curve drawn between velocity and frequency of a photon in vacuum will be a

(a) straight line parallel to frequency axis (b) straight line parallel to velocity axis

(c) staright line passing through origin and making an angle of 45° with frequency axis (d) hyperbola

51) Light described at a place by the equation $E = (100\ V/m)\ [\sin(6 \times 10^{15} s^{-1})t + \sin(8 \times 10^{15} s^{-1})t]$ falls on a metal surface having work function 2.28eV. The maximum energy of the photoelectrons is: (use h = $6.63 \times 10^{-34} Js$)

(a) 2.28eV (b) 3.0eV (c) 1.24eV (d) 1.50eV

52) The momentum of a photon of an electromagnetic radiation is $4.3 \times 10^{-29} kgm/s$ what is the frequency of the associated waves?$h = 6.63 \times 10^{-34} Js, c = 3 \times 10^8 m/s$

(a) $1.5 \times 10^{13} Hz$ (b) $1.95 \times 10^{13} Hz$ (c) $5.6 \times 10^{13} Hz$ (d) $3.9 \times 10^{13} Hz$

53) The wavelength of a KeV photon is $1.24 \times 10^{-9} m$. What is the frequency of 1 MeV photon?

(a) $1.24 \times 10^{15} Hz$ (b) $2.4 \times 10^{20} Hz$ (c) $1.24 \times 10^{18} Hz$ (d) $2.4 \times 10^{23} Hz$

54) Ultraviolet light of wavelength 300nm and intensity 1.0 watt/m^2 falls on the surface of a photosensitive material. If one percent of the incident photon produce photoelectron then the number of photoelectrons emitted per second from an area 1.0cm^2 of the surface is nearly. $h = 6.6 \times 10^{-34} Js$

(a) 2.13×10^{11} (b) 1.51×10^{12} (c) 4.12×10^{13} (d) 9.61×10^{14}

55) We may state that the energy E of a photon of frequency v is E = hv, where h is Plank's constant.The momentum p of a photon is $p = h/\lambda$. where λ is the wavelength of the photon.From the above statement one may conclude that the wave velocity of light is equal to

(a) $3 \times 10^8 m/s$ (b) E/p (c) Ep (d) $(E/p)^2$

56) A sodium lamp emits 3.14×10^{20} photons per second. Calculate the distance from sodium lamp where flux of photon is one photon per second per cm^2.

(a) $10^{10} cm$ (b) $5 \times 10^9 cm$ (c) $5 \times 10^8 cm$ (d) $10^9 cm$

57) A 200 W sodium street lamp emits yellow light of wavelength. Assuming it to be 25% efficient in converting electrical energy to light, the number of photons of yellow light it emits per second is

(a) 5×10^{20} (b) 6×10^{18} (c) 62×10^{20} (d) 3×10^{19}

58) One gram mass falls through a height 2 cm. If whole of the energy fall is converted into light of wavelength $h = 6.63 \times 10^{-7} Js$ how many photons would be produced? Given $h = 6.63 \times 10^{-7} Js; g = 10 m/s^2$

(a) 3.33×10^{14} (b) 3.33×10^{15} (c) 6.67×10^{14} (d) 6.67×10^{15}

59) A parallel beam of monochromatic light of wavelength 500nm is incident normally on a perfectly absorbing surface. The power through any cross-section of the beam is 10W. The force exerted by the light beam on the surface is: Use hc = 1240eV nm.

(a) $1.11 \times 10^{-8} N$ (b) $2.22 \times 10^{-8} N$ (c) $3.33 \times 10^{-8} N$ (d) $6.66 \times 10^{-8} N$

60) A beam of light of wavelength 400nm and power 1.55 mW is directed at the cathode of a photoelectric cell. If only 10% of the incident photons effectively produce photoelectron, then find current due to these electrons. (Given, $hc = 1240eVnm, e = 1.6 \times 10^{-19}C$)

(a) $5\mu A$ (b) $40\mu A$ (c) $50\mu A$ (d) $114\mu A$

61) An X-ray tube operates at 10KV. The ratio of X-ray wavelength to the de-Broglie wavelength is

(a) 10 : 1 (b) 1 : 10 (c) 1 : 100 (d) 100 : 1

62) An electron accelerated under a potential difference V volt has a certain wavelength. λ Mass of proton has to have the same wavelength λ then it will have to be accelerated under a potential difference of

(a) $V volt$ (b) $1840V volt$ (c) $V/1840 volt$ (d) $\sqrt{1840}Volt$

63) If λ_1 and λ_2 denote the wavelength of de-Broglie waves for electron in Bohr's First and second orbits in the hydrogen atom, then $\frac{\lambda_1}{\lambda_2}$ will be

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

64) For Bragg's diffraction by a crystal to occur, then the X-ray of wavelength λ and interatomic distance d must be

(a) λ is greater than 2d (b) λ equals 2d (c) λ is smaller than or equal to 2d (d) λ is smaller than 2d

65) The energy that should be added to an electron to reduce its de-Broglie wavelength from 2×10^{-9} to 0.5×10^{-9} will be

(a) 1.1 MeV (b) 0.56MeV (c) 0.56KeV (d) 5.6 eV

66) The kinetic energy of an electron gets quadrupled then the de-Broglie wavelength associated with it changes by the factor.

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

67) The ratio between masses of two particles is 1:2 and ratio between their temperatures is also 1:2 The ratio between their de-Broglie wavelength

(a) 1:2 (b) 2:1 (c) 1:3 (d) 3:1

68) The de-Broglie wavelength of the tennis ball of mass 60g moving with a velocity of 10m/s is approximately: (Plank's constant h = $h = 6.63 \times 10^{-34}Js$

(a) $10^{-33}m$ (b) $10^{-31}m$ (c) $10^{-16}m$ (d) $10^{-25}m$

69) The de-Broglie wavelength associated with proton changes by 0.25% if its momentum is changed by p_0 . The initial moemntum was

(a) 100p_0 (b) p_0 /400 (c) 401 p_0 (d) p_0 /100

70) The de-Broglie wavelength of a particle moving with a velocity $2.25 \times 10^8 m/s$ is equal to the wavelength of photon. The ratio of kinetic energy of a particle to the energy of the photon is (velocity of light is $3 \times 10^8 m/s$)

(a) 1/8 (b) 3/8 (c) 5/8 (d) 7/8

71) The energy of a photon is equal to the K.E. 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^0 (b) $E^{1/2}$ (c) E^{-1} (d) E^{-2}

72) If the kinetic energy of the particle is increased to 16 times, the percentage change in the de-Broglie wavelength of the particle is

(a) 25% (b) 75% (c) 60% (d) 50%

73) The moving proton and α particle are subjected to the same magnetic field so that the radii of their paths are equal to each other.Assuming the field induction is $\vec{B}$ perpendicular to the velocity vector of the α particle and proton, the ratio of de-Broglie wavelength of α particle to that of proton is

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

74) The ratio of de-Broglie wavelength of molecules of hydrogen and helium in two gas jars kept separately at temperature of $27^{\circ}C$ and $127^{\circ}C$

(a) $\frac{2}{\sqrt{3}}$ (b) $2/3$ (c) $\frac{\sqrt{3}}{8}$ (d) $\sqrt{\frac{8}{3}}$

75) What is the de-Broglie wavelength of the particle accelerated through a potential difference V? Given, $h = 6.63 \times 10^{-34} Js$ mass of a nucleon = $1.66 \times 10^{-27} kg$

(a) $\frac{12.27}{\sqrt{V}}\overset{\circ}{A}$ (b) $\frac{0.202}{\sqrt{V}}\overset{\circ}{A}$ (c) $\frac{0.101}{\sqrt{V}}\overset{\circ}{A}$ (d) $\frac{0.287}{\sqrt{V}}\overset{\circ}{A}$

76) The de-Broglie wavelength of electron in ground state of hydrogen atom is:[The radius of the first orbit of hyfrogen atom is 0.53 $\overset{\circ}{A}$

(a) 0.52$\overset{\circ}{A}$ (b) 1.06$\overset{\circ}{A}$ (c) 1.67$\overset{\circ}{A}$ (d) 3.33$\overset{\circ}{A}$

77) A free particle with inintial kinetic energy E, de-Broglie wavelength enters a region where in it has a potential energy V, what is the new de-Broglie wavelength?

(a) $\lambda(1 - V/E)$ (b) $\lambda(1 + V/E)$ (c) $\lambda(1 - V/E)^{1/2}$ (d) $\lambda(1 + V/E)^2$

78) λ_e, λ_p and λ_α are the de-Broglie wavelengths of electron, proton and α particle. If all are accelerated by potential, then

(a) $\lambda_e, < \lambda_p < \lambda_\alpha$ (b) $\lambda_e, < \lambda_p > \lambda_\alpha$ (c) $\lambda_e, > \lambda_p < \lambda_\alpha$ (d) $\lambda_e, = \lambda_p > \lambda_\alpha$
(e) $\lambda_e, > \lambda_p > \lambda_\alpha$

79) The ratio of the de-Broglie wavelengths of an electron of energy 10 eV to that of a person of mass 66kg travelling with a speed of 100 km/h is of the order of

(a) 10^{34} (b) 10^{27} (c) 10^{17} (d) 10^{-10}

80) Electrons used in an electron microscope are accelerated by a voltage of 25kV. If the voltage is increased to 100 kV then the de-Broglie wavelength associated with the electrons would

(a) increase by 2 times (b) decrease by 2 times (c) decrease by 4 times (d) increase by 4 times

81) After absorbing a slowly moving neutron of mass m_N (momentum$\sim$ 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 then de Broglie wavelength of the other nucleus will be

(a) 25λ (b) 5λ (c) $\lambda/5$ (d) λ

82) An α particle moves in a circular path of radius 0.83 cm in the presence of a magnetic field of 0.25 Wb/m^2. The de-Broglie wavelength associated with the particle will be:

(a) 1A (b) 0.1A (c) 10A (d) 0.01A

83) If the momentum of electron is changed by P, then the de Broglie wavelength associated with it changes by 0.5%. The initial momentum of electron will be:

(a) 200 P (b) 400 P (c) P/200 (d) 100 P

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

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

85) 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 decrease (d) the stopping potential will increase

86) Choose the incorrect statement:

(a) The velocity of photoelectrons is directly proportional to the square root of wavelength of light

(b) The number of photoelectrons emitted depends upon the intensity of incident light

(c) The velocity of photoelectrons is directly proportional to the frequency of incident light.

(d) The velocity of photoelectrons is inversely proportional to square root of the frequency of the light.

87) Photoelectric effect supports the quantum nature of light because

(a) there is minimum frequency of light below which no photoelectrons are emitted

(b) the maximum K.E. of photoelectrons emitted depends only on the frequency of the incident light and on its intensity

(c) even when metal surface is faintly illuminated, the photoelectrons leave the surface immediately

(d) electric charge of photoelectron is quantised

88) The maximum K.E of photoelectrons ejected from a photometer when it is irradiated with radiation of wavelength 400nm is 1eV. If the threshold energy of the surface is 1.9eV.

(a) the maximum K.E. of photoelectrons when it is irradiated with 500nm photons will be 0.42eV

(b) the maximum K.E. of photoelectrons when it is viradiated with 500nm photons will be 0.42eV

(c) maximum K.E will increase if the intensity of radiation is increased

(d) the longest wavelength which will eject the photoelectron from the surface is nearly 610nm

89) An electron and proton have the same de-Broglie wavelength. The K.E of the electron is

(a) zero (b) infinity (c) equal to K.E of the proton (d) greater than K.E. of proton

90) When a momentum point source of light is at a distance of 0.2m front a photoelectric cell, the cutoff voltage and the saturation current are respectively 0.6V and 18.0 mA. If the same source is placed 0.6m away from the photoelectric cell, then

(a) the stopping potential will be 0.2 volt (b) the stopping potential will be 0.6 volt

(c) the saturation current will be 6.0 mA (d) the saturation current will be 2.0 mA

91) Which of the following characteristics of photoelectric effect supports the particle nature of radiations

(a) threshold frequency (b) instantaneous photoelectric emission

(c) independent of the velocity of photo-electrons on intensity of radiations

(d) dependence of the velocity of photoelectrons on frequency

92) The frequency and intensity of a light source are both doubled.Which of the following statement(s) is/are true?

(a) The saturation photocurrent gets doubled. (b) The saturation photocurrent remains almost the same.

(c) The maximum K.E. of the photoelectron is more than doubled.

(d) The maximum K.E. of the photoelectron gets doubled

93) If v is frequency, λ is the wavelength and $\overline{v}$ is the wave number then the energy of a photon can be represented by

(a) hv (b) $hc\overline{v}$ (c) $hc\,\lambda$ (d) hc/λ

94) Lenard observed that no electrons are emitted when frequency of light is less than a certain minimum frequency. This minimum frequency depends on

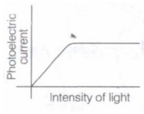
(a) potential differenceof emitter and collectorplates (b) distancebetween collectorand the emitter plate

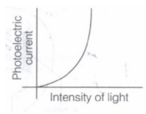
(c) size(area)of the emitter plate (d) material of the emitter plate

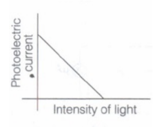
95) The work function of a metal is hc/ λ_0 If light of wavelength Ais incident on its surface, then the essential condition for the electron to come out from the metal surface is

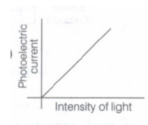
(a) $\lambda \geq \lambda_0$ (b) $\lambda \geq 2\lambda_0$ (c) $\lambda \leq \lambda_0$ (d) $\lambda \leq \lambda_0/2$

96) Variation of photoelectric current with intensity of light is

(a) 

(b) 

(c) 

(d) 

97) A photon of energy 3.4 eV is incident on a metal surface whose work function is 2 eV. Maximum kinetic energy of the photoelectron emitted by the metal surface will be

(a) 1.4 eV (b) 1.7 eV (c) 5.4 eV (d) 6.8 eV

98) Consider a beam of electrons (each electron with energy Eo) incident on a metal surface kept in an evacuated chamber. Then

(a) no electronswillbe emittedas onlyphotons can emit electrons

(b) electronscan be emittedbut all with an energy,E_0

(c) electronscan be emittedwith any energy,with a maximumof $E_0 - \varphi$ (φ is the work function)

(d) electronscan be emittedwith any energy,with a maximumof E_0

99) The formula for kinetic mass of a moving photon is

(a) hv/ λ (b) hλ/e (c) hv/e (d) h/cλ

100) The wavelength of a photon needed to remove a proton from a nucleus which is bound to the nucleus with 1MeV energy is nearly

(a) 1.2 nm (b) 1.2 x 10^{-3} nm (c) 1.2 x 10^{-6}nm (d) 1.2 x 10 nm

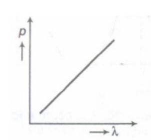
101) The de-Broglie wave of a moving particle does not depend on

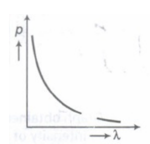
(a) mass (b) charge (c) Velocity (d) momentum

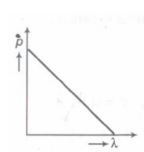
102) The de-Broglie wavelength of a particle of KE, K is λ. What will be the wavelength of the particle, if it's kinetic energy is $\frac{\bar{K}}{9}$?

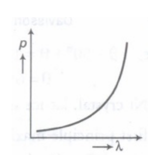
(a) λ (b) 2λ (c) 3λ (d) 4λ

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

(a) 

(b) 

(c) 

(d) 

104) In the Davisson-Germer experiment, suppose the voltage applied to anode is increased. The diffracted beam will have the maximum at a value of θ that

(a) will be larger than the earlier value (b) willbe the sameas the earlier value

(c) will be less than the earlier value (d) will dependon the target

105) Work-function is

(a) maximumpossible energy acquired by an electron (b) energy of electrons in valence shell

(c) minimumenergy required by an electron to move out of metal surface

(d) maximumenergy which is given to electron to move it out ofmetal surface

106) The work function of platinum is 6.35 eV. The threshold frequency of platinum is

(a) 1532 x 10^{14} Hz (b) 1532 x 10^{16} Hz (c) 1532 x 10^{19} Hz (d) 1532 x 10^{18} Hz

107) With the increase in potential difference of emitter and collector, the photoelectric current

(a) increases (b) decreases (c) remains constant (d) increases initially and then become constant

108) The photoelectric threshold frequency of a metal is v. When light of frequency 6v is incident on the metal, the maximum kinetic energy of the emitted photo electron is

(a) 4hv (b) 5hv (c) 3hv (d) (3/2)hv

109) Light of wavelengths λ_A and λ_B falls on two identical metal plates A and B respectively. The maximum kinetic energy of photoelectrons is K_A and K_B respectively, then which one of the following relations is true? $(\lambda_A = 2\lambda_B)$

(a) $K_A < \frac{K_B}{2}$ (b) $2K_A = K_B$ (c) $K_A = 2K_B$ (d) $K_A > 2K_B$

110) All photons present in a light beam of single frequency have

(a) same frequency but different momentum (b) same momentum but different frequency

(c) different frequency and different momentum (d) same frequency and same momentum

111) The linear momentum of a 6 MeV photon is

(a) 0.01 eV sm^{-1} (b) 0.02 eV sm^{-1} (c) 0.03 eV sm^{-1} (d) 0.04 eV sm^{-1}

112) A photocell converts

(a) change in current into change in light intensity (b) change in intensity of light into change in current

(c) change in current into change in voltage (d) change in intensity into change in potential difference

113) The de-Broglie wavelength (λ) of equal mass particles depends upon the mass in the following way

(a) $\lambda \propto m$ (b) $\lambda \propto m^{1/2}$ (c) $\lambda \propto m^{-1}$ (d) $\lambda \propto m^{-1/2}$

114) Light of frequency 1.9 times the threshold frequency is incident on a photosensitive material. If the frequency is halved and intensity is doubled, the photocurrent becomes

(a) quadrupled (b) doubled (c) halved (d) zero

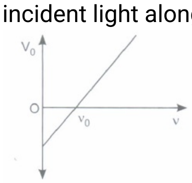
115) Threshold wavelength for a metal having work function W_0 is λ. What is the threshold wavelength for the metal having work function $2W_0$?

(a) 4λ (b) 2λ (c) λ/2 (d) λ/4

116) Radiations of frequency v are incident on a photosensitive metal. The maximum K.E. of the photoelectrons is E. When the frequency of the incident radiation is doubled, what is the maximum kinetic energy of the photoelectrons?

(a) 2E (b) 4E (c) E + hv (d) E - hv

117) The stopping potential Vo for photoelectric emission from a metal surface is plotted along y-axis and frequency v of incident light along x-axis. A straight line is obtained as shown. Planck's constant is given by



(a) slope of the line (b) product of the slope of the line and charge on electron

(c) intercept along y-axis divided by charge on the electron

(d) product of the intercept along x-axis and mass of the electron

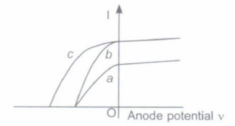
118) The energy of photon of wavelength 450 nm is

(a) 2.5×10^{-17} J (b) 1.25×10^{-17} J (c) 4.4×10^{-19} J (d) 2.5×10^{-19} J

119) The kinetic energy of an electron is 5 eV. Calculate the de broglie wavelength associated with it. ($h = 6.6 \times 10^{-34}$ Js, $m_e = 9.1 \times 10^{-31}$ kg)

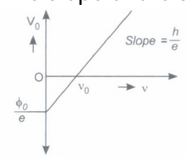
(a) $5.47\mathring{A}$ (b) $10.9\mathring{A}$ (c) $2.7\mathring{A}$ (d) None of these

120) 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 v_a, v_b and v_c be the frequencies for the curves a, b and c respectively. Then the correct relation is



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

121) The slope of the stopping potential versus frequency graph for photoelectric effect is equal to



(a) h (b) he (c) h/e (d) e

122) A proton and an α-particle are accelerated by the same potential difference. The ratio of their de broglie wavelengths $(\lambda_p/\lambda_\alpha)$ is

(a) 1 (b) 2 (c) $\sqrt{8}$ (d) $\frac{1}{\sqrt{8}}$

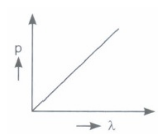
123) Work function of three metals A, B and C are 4.5 eV, 4.3 eV and 3.5 eV respectively. If a light of wavelength 4000 $\overset{\circ}{A}$ is incident on the metals then

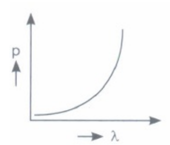
(a) photoelectrons are emitted from A. (b) photoelectrons are emitted from B.
(c) photoelectrons are emitted from C. (d) photoelectrons are emitted from all the metals

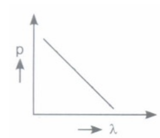
124) The photoelectric effect can be explained by

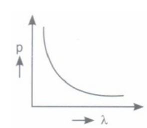
(a) Corpuscular theory of light (b) Wave nature of light (c) Bohr's theory (d) Quantum theory of light

125) Which of the following figure represents the variation of particle momentum and associated de Broglie wavelength?

(a) 

(b) 

(c) 

(d) 

126) If K.E. of free electron is doubled, its de Broglie wavelength will change by factor

(a) $\frac{1}{\sqrt{2}}$ (b) $\sqrt{2}$ (c) 1/2 (d) 2

127) Work function of metal is

(a) the minimum energy required to free an electron from surface against coulomb forces.
(b) the minimum energy required to free an nucleon (c) the minimum energy to ionise an atom.
(d) the minimum energy required to eject an electron orbit.

128) The rest mass of a photon of wavelength λ is

(a) zero (b) $\frac{h}{c\lambda}$ (c) $\frac{h}{\lambda}$ (d) $\frac{hc}{\lambda}$

129) Photoelectric effect is based on the law of conservation of

(a) energy (b) mass (c) linear momentum (d) angular momentum

130) Einstein's photoelectric equation is:

(a) $hv = hv_0 + \frac{1}{2}mv^2$ (b) $hv_0 = hv + \frac{1}{2}mv^2$ (c) $hv = hv_0 - \frac{1}{2}mv^2$
(d) $2hv = hv_0 + mv^2$

131) In photoelectric effect, the number of photoelectrons emitted is proportional to

(a) intensity of incident beam. (b) frequency of incident beam. (c) velocity of incident beam.

(d) work function of photo cathode.

132) For a given kinetic energy which of the following has smallest de Broglie wavelength?

(a) Electron (b) Proton (c) Deutron (d) α-particle

133) Which of the following shows particle nature of light?

(a) Photoelectric effect (b) Refraction (c) Interference (d) Polarisation

134) A proton, a neutron, an electron and an a-particle have same energy. Then their de Broglie wavelengths compare as

(a) $\lambda_p = \lambda_n > \lambda_e > \lambda_\alpha$ (b) $\lambda_\alpha < \lambda_p = \lambda_n < \lambda_e$ (c) $\lambda_e < \lambda_p = \lambda_n > \lambda_\alpha$

(d) $\lambda_e = \lambda_p = \lambda_n = \lambda_\alpha$

135) A particle moves in a closed orbit around the origin, due to a force which is directed towards the origin. The de Broglie wavelength of the particle varies cyclically between two values λ_1, λ_2 with $\lambda_1 > \lambda_2$ Which following statements are true?

(a) The particle could not be moving in a circular orbit with origin as centre.

(b) The particle could not be moving in an elliptic orbit with origin as its focus.

(c) When the de Broglie wavelength is λ_1 the particle is nearer the origin than when its value is λ_2.

(d) When the de Broglie wavelength λ_2, the particle is nearer the origin than when its value λ_1.

136) In photoelectric effect what determines the maximum velocity of electron reacting the collector?

(a) Frequency of incident radiation alone (b) Work function of metal

(c) Potential difference between the emitter and the collector (d) All of these

137) Consider the following statements:
I. According to de Broglie hypothesis, particles have wave-like characteristics.
II. When an electron and a proton have the same de Broglie wavelength, they will have equal momentum.
Which of the above statements is/are correct?

(a) I only (b) II only (c) both I and II (d) neither I nor II

138) A Proton and an α-particle have the same de Broglie wavelength. What is same for both of them?

(a) Mass (b) Energy (c) Frequency (d) Momentum

139) The energy of a photon of wavelength 663 nm is

(a) 6.64×10^{-20} J (b) 5.18×10^{-10}J (c) 3.0×10^{-19}J (d) 2.0×10^{-20} J

140) The energy of a photon of wavelength λ is

(a) $hc\lambda$ (b) hc/λ (c) λ/hc (d) $\lambda h/c$

141) A photon of wavelength 663 nm is incident on a metal surface. The work function of the metal is 1.50 eV. The maximum kinetic energy of the emitted photon electron is

(a) 3.0×10^{-20}J (b) 6.0×10^{-20}J (c) 4.5×10^{-20}J (d) 9.0×10^{-20}J

142) A proton and an alpha particle have the same kinetic energy. The ratio of de-Broglie wavelengths associated with the prorton to that with the alpha particle is

(a) 1 (b) 2 (c) $2\sqrt{2}$ (d) $\frac{1}{2}$

143) Photons of energy 3.2 eV are incident on a photosensitive surface. If the stopping potential for the emitted electrons is 1.5 V, the work function for the surface is

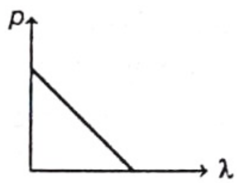
(a) 1.5 eV (b) 1.7 eV (c) 3.2 eV (d) 4.7 eV

144) If photons of frequency v are incident on the surfaces of metals A and B of threshold frequencies $\frac{v}{2}$ and $\frac{v}{3}$ respectively, the ratio of the maximum kinetic energy of electrons emitted from A to that from B is

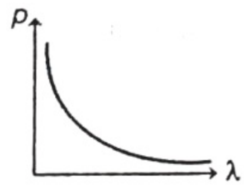
(a) 2 : 3 (b) 3 : 4 (c) 1 : 3 (d) $\sqrt{3} : \sqrt{2}$

145) The graph showing the correct variation of linear momentum (p) of a charge particle with its de-Broglie wavelength (λ) is

(a)

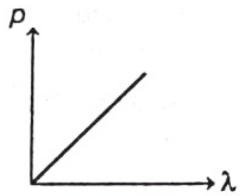


(b)



(c)

(d)



146) Photons of frequency v are incident on the surfaces of two metals A and B of threshold frequencies (3/4) v and (2/3) v, respectively. The ratio of maximum kinetic energy of electrons emitted from A to that from B is

(a) 2 : 3 (b) 4 : 3 (c) 3 : 4 (d) 3 : 2

Fill up / 1 Marks 26 x 1 = 26

147) The minimum energy required by an electron to just.....from the metal surface so as to overcome the restraining forces at the surfaces is called.......

148) The maximum kinetic energy of emitted photoelectrons depends on the......and nature of.....but is independent of......

149) The ratio of number of photoelectrons ejected to the number of the photons falling on a metal surface is.......than........

150) For a given photosensitive material, the photoelectric current is.......on decreasing the wavelength of incident radiation, without any change in intensity of radiation.

151) An increase in the frequency of the incident light...........the velocity with which photoelectron is ejected.

152) The minimum frequency required to eject an electron from the surface of a metal is called............

153) In photoelectric effect, the energy of the free electron does not depend on.........of light.

154) Photon is not a ......but it is a........

155) The velocity of photon in different media is.......

156) The intensity of light depends upon the........present in light.

157) The momentum of a photon of energy E is...........and of wavelength λ is......

158) de-Broglie waves are associated with a moving particle irrespective of.........on it.

159) The de-Broglie wavelength of a photon of an electromagnetic radiation is.........the wavelength of the radiation

160) A photon and electron have got same de-Broglie wavelength. Total energy of an electron is .... than that of photon.

161) The expression for de-Broglie wavelength of an electron moving under a potential difference of V volt is.........

162) The main aim of Davisson-Germer experiment is to verify.........

163) According to Planck's quantum theory of radiation, an electromagnetic wave travels in the form packets of energy called ________.

164) _________ experiment has varified and confirmed the wave nature of electrons.

165) Photoelectric emission occurs only when the frequency of incident radiation is __________ than threshold frequency.

166) Photoelectric emission is an _________ process.

167) De Broglie wavelength associated with an electron beam accelerated through a potential difference V is _______ proportional to $\sqrt{V}$

168) ___________ is the minimum amount of energy required to cause photoelectric emission.

169) Wave associated with the material particle is known as ________.

170) Maximum photoelectric current at particular intensity of incident radiation, which becomes independent of anode potential is known as __________.

171) Stopping potential is _________ of intensity of incident radiation but proportional to _________ of the radiation.

172) Kinetic energy and stopping potential are zero, when frequency of incident radiation is equal to ___________.

Assertion and reason 15 x 1 = 15

173) **Assertion (A)** : The threshold frequency of photoelectric effect supports the particle nature of light.
Reason (R) : If frequency of incident light is less than the threshold frequency, electrons are not emitted from metal surface.
Codes
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false and R is also false

174) **Assertion (A)** : Mass of moving photon varies inversely to the wavelength.
Reason (R) : Energy of the particle = Mass x (Speed of light)^2?
Codes:
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false and R is also false

175) **Assertion (A)** : An electron microscope can achieve better resolving power than an optical microscope.
Reason (R) : The de- Broglie wavelength of the electrons emitted from an electron gun with velocity 500 ml s is much less than 500 nm.
Codes
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false and R is also false

176) **Assertion (A)** : Work function of aluminium is 4.2 ev' Emission of electrons will not be possible if two photons each of energy 2.5 eV stnike an electron of aluminium.
Reason (R) : For photoelectric emission the energy of each photon should be greater than the work function of aluminium.
Codes:
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false and R is also false

177) **Assertion (A)** : Some photographic plates are not affected by red light but are immediately blackened by white light.
Reason (R) : The wavelength of red light is less than the wavelength of many components of white light.
Codes:
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false and R is also false

178) **Assertion (A)** : The de-Broglie wavelength of particle having kinetic energy K is λ. If its kinetic energy becomes 4 K then its new wavelength would be $\lambda/2$.
Reason (R) : The de- Broglie wavelength λ is inversely proportional to square root of the kinetic energy.
Codes:
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false and R is also false

179) **Assertion (A)** : In photo emissive cell inert gas is used.
Reason (R) : Inert gas in the photoemissive cell gives greater current.
Codes:
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false and R is also false

180) **Assertion (A)** : Photosensitivity of a metal is high if its work function is small.
Reason (R) : Work function = hv_0 where v_0 is the threshold frequency.
Codes:
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false and R is also false

181) **Assertion (A)** :A photon has no rest mass, yet it carries definite momentum.
Reason (R) : Momentum of photon is due to its energy and hence its equivalent mass.
Codes:
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false and R is also false

182) **Assertion (A)** : There is a physical significance of matter waves.
Reason (R) : Both interference and diffraction occurs in it.
Codes:
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false and R is also false

183) **Assertion (A)** : Stopping potential depends upon the frequency of incident light but is independent of the intensity of the light.
Reason (R) : The maximum kinetic energy of the photoelectrons is proportional to stopping potential.
Codes:
(a) Both A and R are true and R is the correct explanation of A
(b) Both A and R are true but R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false and R is also false

184) **Assertion (A)** : As work function of a material increases by some mechanism, it requires greater energy to excite the electrons from its surface.

Reason (R) :A plot of stopping potential (V_s) versus frequency (V) for different metals, has greater slope for metals with greater work functions.

Codes:

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false and R is also false

185) **Assertion (A)** : The de-Broglie wavelength of a neutron when its kinetic energy is K is λ. Its wavelength is 2λ when its kinetic energy is 4 K.

Reason (R) : The de-Broglie wavelength λ is directly proportional to square root of the kinetic energy.

Codes:

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false and R is also false

186) **Assertion (A)** : On increasing the frequency of light, larger number of photoelectrons are emitted.

Reason (R) : The number of electrons emitted is directly proportional to the intensity of incident light.

Codes:

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false and R is also false

187) **Assertion (A)** : Photoelectric effect demonstrates the wave nature of light.

Reason (R) : The number of photoelectrons is proportional to the frequency of light.

Codes:

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false and R is also false

2 Marks 198 x 2 = 396

188) The threshold wavelength for photoelectric emission for a material is 5200$\mathring{A}$. Will the photoelectrons be emitted when this material is illuminated with monochromatic radiation from the 1-watt ultraviolet lamp?

189) How will the photoelectric current change on decreasing the wavelength of incident radiation for a given photosensitive material?

190) The stopping potential in an experiment on a photoelectric effect is 1.5V. What is the maximum kinetic energy of the photoelectrons emitted?

191) Why are alkali metal surfaces most suited as photosensitive surfaces?

192) Does each incident photon essentially eject a photoelectron?

193) A source of light is placed at a distance of 1m. from a photocell and the cutoff potential is found to be.V_0 If the distance is doubled what will be the cutoff potential?

194) Define photoelectric work function. How is it related to threshold frequency?

195) The work function of cesium is 2eV. Explain this statement.

196) The work function of lithium and copper are 2.3eV and 4.0eV respectively. Which of these metals will be useful for the photoelectric cell working with visible light? Explain.

197) It is harder to remove a free electron from copper than from sodium. Which has higher work function?

198) The work function of copper is 4.0eV. If two photons, each of energy 2.5eV strike with some electrons of copper, will the emission be possible?

199) What determines the maximum velocity of the photoelectrons?

200) Define threshold frequency. Is it a constant quantity for a metal surface? Comment.

201) Define space charge. What is its effect on the emission of photoelectrons from a metal surface?

202) Is photoelectric emission possible at all frequencies? Give reason for your answer?

203) Out of microwaves, ultraviolet rays and infra-red rays, which radiations will be most effective for emission of electrons from a metallic surface?

204) Two metals A and B have work functions 4eV and 10eV respectively. Which metal has higher threshold wavelength?

205) Does the stopping potential in photoelectric emission depend upon the intensity of the incident radiation in a photocell? Comment on it.

206) What is the effect of a decrease in frequency of incident radiation on the stopping potential in photoelectric emission?

207) When the frequency of incident radiation is less than threshold frequency for a metal surface, what is the value of stopping the potential for that and why?

208) Two beams one of red light and other of blue light of the same intensity are incidents on a metallic surface to emit photoelectrons. Which one of the two beam emits photoelectrons. Which one of the two beam emits electrons of greater kinetic energy?

209) The photoelectric current at a distance $r_1 and r_2$ of light source from the photoelectric cell is respectively $I_1 and I_2$. Find the value of.I_1/I_2

210) Light of frequency is$2.5v_0$ incident on a metal surface of threshold frequency.$2v_0$ If its frequency is halved and intensity is made three times then find the new value of photoelectric current.

211) How does the maximum kinetic energy of electrons emitted vary with the work function of the metal?

212) The frequency (v) of the incident radiation is greater than threshold frequency in(v_0) a photocell. How will the stopping potential vary if frequency v is increased, keeping other factors constant?

213) If the intensity of the incident radiation in a photocell is increased, how does the stopping potential vary?

214) If h is Planck's constant, find the momentum of a photon of wavelength.$0.01\mathring{A}$

215) What is the energy of a photon in eV corresponding to the visible light of maximum wavelength?

216) What is the momentum of photon of energy 3 MeV in $kg\ ms^{-1}$

217) Which photon is more energetic: A red one or a violet one?

218) Do all the photons of different colors have the same mass? If not, why?

219) Why are de-Broglie waves with a moving football not visible?

220) If an electron behaves like a wave, what should determine the wavelength and frequency of this wave?

221) Is there any difference between light waves and matter waves?

222) Are matter waves electromagnetic? Write the de-Broglie equation.

223) What is the momentum of an electron beam of wavelength $4\mathring{A}$? (h = $6.62 \times 10^{-34} Js$)

224) What is de-Broglie wavelength of an atom of mass m, moving at absolute temperature TK.

225) What inference was drawn from Davisson and Germer experiment regarding nature of electrons

226) The most probable kinetic energy of thermal neutrons at thermal neutrons at a temperature of T Kelvin may be taken equal to kT, where k is Boltzmann constant. Taking the mass of a neutron and its associated de-Broglie wavelength as m and respectivelyλ_B , state the dependence of onλ_B m and T.

227) The de-Broglie Wavelength of a particle of kinetic energy K is λ What would be the de-Broglie wavelength of the particle, if its kinetic energy were K/4?

228) If the temperature is increased from $27^{\circ} C to 127^{\circ} C$ Find the ratio of the de-Broglie wavelength of the wave associated with a material particle at these two temperatures.

229) Name the experiment used to establish the wave nature of electron (i) for slow moving electrons (ii) for fast moving electrons.

230) In Davisson-Germer experiment, if the angle of diffraction is then52°, find the glancing angle.

231) de-Broglie wavelength associated with an electron accelerated through a potential difference V is $\lambda.$ What will be its wavelength when the accelerating potential is increased to 4V?

232) Show graphically, the variation of the de-Broglie wavelength with(λ) the potential (V) through which an electron is accelerated from rest.

233) On what principle is an electron microscope based?

234) Is the de-Broglie wavelength of a photon of an electromagnetic radiation equal to the wavelength of the radiation?

235) The number of ejected photoelectrons increases with an increase in the intensity of light but not with the increase in the frequency of light. Why?

236) An increase in the frequency of the incident light increases the velocity with which photoelectron is ejected. Explain how?

237) Explain the term stopping potential and a threshold frequency.

238) Radiations of frequencies $v_1 and v_2$ are made to fall in turn, on a photosensitive surface. The stopping potentials required for stopping the mist energetic photoelectrons in the two cases are respectively$v_1 and v_2$. Obtain a formula for determining the threshold frequency in terms of these parameters.

239) What is the effect on the maximum velocity of the emitted electron if the wavelength of the incident light is decreased?

240) For a photosensitive surface, threshold wavelength is.λ_0 Does photoemission occur if the wavelength of the incident radiation is (i) more than λ_0 (ii) less thanλ_0 Justify your answer?

241) If we go on increasing the wavelength of light incident on a metal surface, what changes in the number of electrons and the energy take place?

242) The work function for a certain metal is 4.2eV. Will this metal give photoelectric emission for incident radiation of wavelength 330 nm? Use, $h = 6.6 \times 10^{-34} Js$

243) Write two characteristic features observed in photoelectric effect which support the photon picture of electromagnetic radiation.

244) The threshold frequency of a metal is f_0 When the light of frequency $2f_0$ is incident on the metal plate, the maximum velocity of electrons emitted is v_1 When the frequency of the incident radiation is increased to, $5f_0$ the maximum velocity of electrons emitted is $v_2.$ Find the ratio of $v_1 and v_2$

245) Explain how Einstein's photoelectric equation enables us to understand the
(i) linear dependence, of the maximum K.E. of the emitted electrons, on the frequency of the incident radiations
(ii) existence of a threshold frequency for a given photoemitter.

246) Green light ejects photoelectrons from a given photosensitive surface whereas yellow light does not. What will happen in the case of violet and red light? Give a reason for your answer.

247) Ultraviolet light is incident on two photosensitive materials having work function $\phi_1 \ and \ \phi_2.$ In which case will the K.E. of the emitted electrons be greater? Why?

248) Name the device that converts changes in intensity illumination into changes in electric current. Give three applications of this device.

249) Why is a photo-electric cell also called an electric eye?

250) What is a photon? Show that it has zero rest mass or photons can not exist at rest. Explain.

251) If the wavelength of an electromagnetic radiation is doubled, what will happen to (i) the energy of photons and (ii) the momentum of a photon?

252) Why is the wave nature of matter not more apparent to our daily observations?

253) A particle of mass M at rest decays into two particles of masses $m_1 \ and \ m_2$ having non-zero velocities. What is the ratio of the de-Broglie wavelengths of the two particles?

254) A particle with rest mass is m_0 moving with velocity c. What is the de-Broglie wavelength associated with it?

255) An electron and photon have same de-Broglie wavelength. Which one posses greater energy?

256) An electron and a proton have the same de-Broglie wavelength. Which one these have higher kinetic energy? Which one is moving faster?

257) What is the de-Broglie wavelength associated with an electron, accelerated through a potential difference of 100 volt?

258) A proton and an α particle are accelerated, using the same potential difference. How are the de-Broglie wavelength λ_p and λ_a related to each other

259) (i) In the explanation of photoelectric effect, we assume one photon of frequency v collides with an electron and transfer its energy.This leads to the equation for the maximum energy E_{max} of the emitted electron as
$E_{max} = hv - \phi_0$
Where ϕ_0 is the work function of metal.If an electron absorbs two photons(each of frequency v) What will be the maximum energy for the emitted electron?
(ii) Why is this fact(two-photon absorption) not taken into consideration in our discussion of the stopping potential?

260) Do all the electrons that absorb a photon come out as photoelectrons?

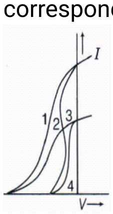
261) Consider a metal exposed to light of wavelength 600nm.The maximum energy of the electron doubles when light of wavelength 400nm is used.Find the work function in eV.

262) Assuming an electron is confined to a 1nm wide region, find the uncertainty in momentum using Heisenberg Uncertainty principle $(\Delta x \Delta p \approx \hbar)$. You can assume uncertainty in position Δx as 1nm. Assuming p = Δp find the energy in electron volts.

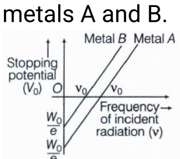
263) A neutron beam of energy E scatters from atoms on a surface with a spacing d = 0.1nm. The first maximum of intensity in the reflected beam occurs at $\theta = 30^\circ$. What is the kinetic energy E of the beam in eV?

264) For a given photosensitive material and with a source of constant frquency of incident radiation, how does the photocurrent vary with the intensity of incident light?

265) The given graph shows the variation of photoelectric current I versus applied voltage V for two different photosensitive materials and for two different intensities of the incident radiations. Identify the pairs of curves that correspond to different materials but same intensity of incident radiation.



266) The graph shows the variation of stopping potential with the frequency of incident radiation for two photosensitive metals A and B.



Which one of the two has higher value of work function? Justify your answer.

267) When radiations of frequency 10^{14} Hz is incident on certain surface, no photoemission takes place. What does this statement mean?

268) Two metals A and B have work functions 2 eV and 4 eV respectively, which metal has lower threshold wavelength for photoelectric effect?

269) Ultraviolet radiations of different frequencies v_1 and v_2 are incident on two photosensitive materials having work functions W_1 and W_2 ($W_1 > W_2$) respectively. The kinetic energy of the emitted electrons is same in both the cases. Which one of the two radiations will be of higher frequency?

270) Two monochromatic radiations, blue and violet, of the same intensity are incident on a photosensitive surface and cause photoelectric emission. Would
(i) the number of electrons emitted per second and
(ii) the maximum kinetic energy of the electrons be equal in the two cases? Justify your answer.

271) Consider figure for photoemission. How would you reconcile with momentum conservation? Note light (photons) have momentum in a different direction than the emitted electrons.

272) Draw a graph to show the variation of stopping potential with frequency of radiation incident on a metal plate. How can the value of Planck's constant be determined from this graph?

273) What consideration led de-Broglie to suggest that material particles can also show wave property?

274) Write the expression for the de-Broglie wavelength associated with a charged particle having charge q and mass m, when it is accelerated by a potential V.

275) A proton and an electron have same kinetic energy. Which one has greater de-Broglie wavelength and why?

276) Show graphically the variation of de-Broglie wavelength λ with the potential V through which an electron is accelerated from rest.
To plot the graph between the two quantities first of all we have to find the relation between the two through the connecting formula.

277) A photon and an electron have been same de-Broglie wavelength which one has higher total energy?

278) The de-Broglie wavelength associated with an electron accelerated through a potential difference V is λ What will its wavelength when the accelerating potential is increased to 4 V?

279) A proton and an α particle are accelerated through the same potential. Which one of the two has
(i) greater value of de-Broglie wavelength associated with it and
(ii) less kinetic energy? Give reasons to justify your answer.

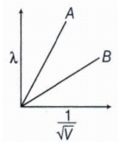
280) Find the ratio of the de-Broglie wavelength associated with protons accelerated through a potential of 128 V and a particles accelerated through a potential of 64 V.
To calculate the ratio of de-Baroglie wavelength of two particle find the ratio in terms of symbols and then put the given numerical values.

281) Calculate
(i) momentum and
(ii) de-Broglie wavelength of the electron accelerated through a potential difference of 56 V

282) What is the
(i) momentum
(ii) speed
(iii) de-Broglie wavelength of an electron with kinetic energy of 120 eV?

283) A proton and α particle have the same de-Broglie wavelength. Determine the ratio of
(i) their accelerating potentials
(ii) their speeds

284) The two lines marked A and B in the given figure. Show a plot of de-Broglie wavelength λ versus $\frac{1}{\sqrt{V}}$, where V is the accelerating potential for two nuclei $_1^2H$ and $_1^3H$.
(i) What does the slope of the lines represent?
(ii) Identify, which of the lines corresponded to these nuclei.



285) Define intensity of radiation on the basis of photon picture of light. Write its S.I. unit.

286) In photoelectric effect, why should the photoelectric current increase as the intensity of monochromatic radiation incident on a photosensitive surface is increased? Explain.

287) Define the term stopping potential in relation to photoelectric effect.

288) A monochromatic source emitting light of wavelength 600 nm a power output of 66 w. Calculate the number of photons emitted by this source in 2 minutes.

289) Write Einstein's photoelectric equation.Explain the terms of threshold frequency

290) Write Einstein's photoelectric equation.Explain the terms of stopping potential.

291) Find the ratio of de-Broglie wavelengths associated with two electrons accelerated through 25 V and 36 V.

292) State de-Broglie hypothesis.

293) The equivalent wavelength of a moving electron has the same value as that of a photon having an energy of 6 x 10^{-17} J. Calculate the momentum of the electron.

294) Write the relationship of de-Broglie wavelength associated with a particle of mass m in terms of its kinetic energy E.

295) An electron is revolving around the nucleus with a constant speed of 2.2 x 10^8 m/s. Find the de Broglie wavelength associated with it.

296) A proton and a deuteron are accelerated through the same accelerating potential. Which one of the two has:
(a) Greater value of de-Broglie wavelength associated with it and
(b) Give reason to justify your answer.

297) A proton and a deuteron are accelerated through the same accelerating potential. Which one of the two has: less momentum? Give reason to justify your answer.

298) An electron is accelerated through a potential difference of 100 volts. What is the de-Broglie wavelength associated with it? To which part of the electromagnetic spectrum does the value of wavelength correspond?

299) An α -particle and a proton are accelerated from rest by the same potential. Find the ratio of their de-broglie wavelengths.

300) Show graphically how the stopping potential for a given photosensitive surface varies with the frequency of incident radiations.

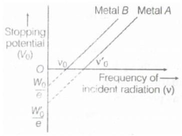
301) Write three basic properties of photons which are used to obtain Einstein's photoelectric equation. Use this equation to draw a plot of maximum kinetic energy of the electrons emitted versus the frequency of incident radiation.

302) (i) Monochromatic light of frequency 6.0 x 1014 Hz is produced by a laser. The power emitted is 2.0 x 10^{-3} W. Estimate the number of photons emitted per second on an average by the source.
(ii) Draw a plot showing the variation of photoelectric current versus the intensity of incident radiation on a given photosensitive surface.

303) X-rays fall on a photosensitive surface to cause photoelectric emission. Assuming that the work function of the surface can be neglected, find the relation between the de-Broglie wavelength (λ) of the electrons emitted to the energy (E_v) of the incident photons. Draw the nature of the graph for Aas a function of E_v.

304) Two monochromatic radiations of frequencies v_1 and v_2 ($v_1 > v_2$) and having the same intensity are, in turn, incident on a photosensitive surface to cause photoelectric emission. Explain, giving reason, in which case
(i) more number of electrons will be emitted and
(ii) the maximum kinetic energy of the emitted photoelectrons will be more.

305) The graph shows variation of stopping potential V_o versus frequency of incident radiation v for two photosensitive metals A and B. Which one of the two metals has higher threshold frequency and why?



306) Show on a plot the nature of variation of photoelectric current with the intensity of radiation incident on a photosensitive surface.

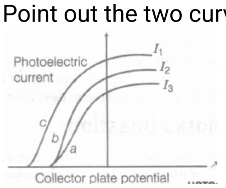
307) Why is photoelectric emission not possible at all frequencies?

308) Show the variation of photoelectric current with collector plate potential for different frequencies but same intensity of incident radiation.

309) The maximum kinetic energy of a photoelectron is 3eV. What is its stopping potential?

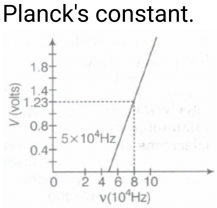
310) The stopping potential in an experiment on photoelectric effect is 2 V. What is the maximum kinetic energy of the photoelectrons emitted?

311) The figure shows a plot of three curves a, b, c showing the variation of photocurrent versus collector plate potential for three different intensities I_1,I_2 and I_3 having frequencies v_1, v_2 and v_3, respectively incident on a photosensitive surface.
Point out the two curves for which the incident radiations have same frequency but different intensities.



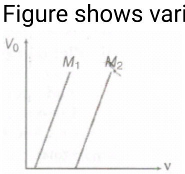
312) In the wave picture of light, intensity of light is determined by the square of the amplitude of the wave. What determines the intensity in the photon picture of light?

313) Using the graph shown in the figure for stopping potential versus the incident frequency of photons, calculate Planck's constant.



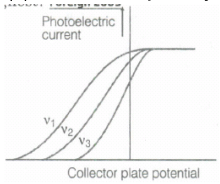
314) Write Einstein's photoelectric equation. State clearly the three salient features observed in photoelectric effect which can be explained on the basis of above equation.

315) Figure shows variation of stopping potential (V_o) with the frequency (v) for two photosensitive materials M_1 and M_2.



(i) Why is the slope same for both lines?
(ii) For which material will the emitted electrons have greater kinetic energy for the incident radiation of the same frequency? Justify your answer.

316) The given graph shows variation of photoelectric current with collector plate potential for different frequencies of incident radiation.
(i) Which physical parameter is kept constant for the three curves?
(ii) Which frequency (v_1,v_2 or v_3) is the highest?



317) Plot a graph showing variation of stopping potential (v_o) with the frequency (v) of the incident radiation for a given photosensitive material. Hence, state the significance of the threshold frequency in photoelectric emission. Using the principle of energy conservation, write the equation relating the energy of incident photon, threshold frequency and the maximum kinetic energy of the emitted photoelectrons.

318) Draw a plot showing the variation of de-Broglie wavelength of electron as a function of its KE.

319) Figure shows a plot of $\frac{1}{\sqrt{V}}$, where V is the accelerating potential, versus the de-Broglie wavelength λ in the case of two particles having same charge q but different masses m_1 and m_2 Which line (A or B) represents a particle of large mass?

320) A particle is moving three times as fast as an electron. The ratio of the de Broglie wavelength of the particle to that of the electron is 8.3 x 10^{-4}. Calculate the particle's mass and identify the particle.

321) Name an experiment which shows wave nature of the electron. Which phenomenon was observed in this experiment using an electron beam?

322) Which an electron in hydrogen atom jumps from the third excited state to the ground state, how would the de-Broglie wavelength associated with the electron change? Justify your answer.

323) A deuteron and an a-particle are accelerated with the same accelerating potential. Which one of the two has
(i) greater value of de-Broglie wavelength, associated with it and
(ii) less kinetic energy? Explain.

324) The ratio between the de-Broglie wavelengths associated with protons, accelerated through a potential of 512 V and α -particles, accelerated through a potential of X volt is found to be one. Find the value of X.

325) Derive an expression for the de-Broglie wavelength associated with an electron accelerated through a potential V. Draw a schematic diagram of a localised wave describing the wave nature of the moving electron.

326) Calculate the ratio of the accelerating potential required to accelerate a proton and an α -particle to have the same de-Broglie wavelength associated with them.

327) The work function (W), of a metal X, equals 3 x 10^{-19}. Calculate the number (N) of photons, of light of wavelength 26.52 nm, whose total energy equals W.

328) A monochromatic light source of power 5 mW emits 8 x 10^{15} photons per second. This light ejects photoelectrons from a metal surface. The stopping potential for this set up is 2V. Calculate the work function of the metal.

329) The Kinetic Energy (K.E.), of a beam of electrons, accelerated through a potential V, equals the energy of a photon of wavelength 5460 nm. Find the de Broglie wavelength associated with this beam of electrons.

330) Find the ratio of the de Broglie wavelengths, associated with
(i) protons, accelerated through a potential of 128 V, and
(ii) α -particles, accelerated through a potential of 64 V.

331) Plot a graph showing variation of de Broglie wavelength λ versus , where V is accelerating potential for two particles Aand B carrying same charge but of masses m_1, m_2 (m_1 > m_2). Which one of the two represents a particle of smaller mass and why?

332) Calculate the de Broglie wavelength of the electron orbiting in the n = 2 state of hydrogen atom.

333) If wavelength of electromagnetic waves are doubled what will happen to energy of photon?

334) Alkali metals are most suitable for photoelectric emission. Why?

335) Can X-rays cause photoelectric effect?

336) If the intensity of incident radiation on a metal is doubled what happens to the K.E of electrons emitted?

337) What is the value of stopping potential between the cathode and anode of photocell? If the max K.E of electrons emitted is 5eV?

338) What is the role of photocell in cinematography?

339) An electron and photon possessing same K.E. Which one will have greater wavelength?

340) In Davisson – Germer experiment if the angle of diffraction is 520 find Glancing angle?

341) What is the energy associated with a photon of wavelength 6000 A^0 ?

342) What is the effect on the velocity photo electrons, if the wavelength of incident light is decreased?

343) The de-broglie wave length of a photon is same as the wave length of electron. Show that K.E. of a photon is 2mc λ /h times K.E. of electron. Where ‘m’ is mass of electron,c is velocity of light.

344) Light from bulb falls on a wodden table but no photon electrons are emitted why ?

345) Following table gives values of work function for a few photosensitive metal

S.NO	**METAL**	**WORK FUNCTIONS**
1	Na	1.92
2	K	2.15
3	Mo	4.17

If each metal is exposed to radiation of wavelength 300nm which of them will not emit photo electron

346) An electron and alpha particle and proton have same kinetic energy , which have shortest De-broglie wavelength?

347) The De-broglie wave length associated with proton and neutron are equal.Which has greater kinetic energy?

348) A stream of electron travelling with a speed at right angle to a uniform electric field E, is deflected in a circular path of radius “r” . Prove that e/m = v2 /rE.

349) If the potential difference used to accelerate electron is doubled , by what factor the Debroglie wave length of the electron beam changed

350) The De-broglie wave length associated with an electron accelerated through the potential difference “V” is λ . What will be its wave length , when accelerating potential is increased to 4v?

351) Visible light can not eject photo electrons from copper surface, whose work function is 4.4 ev , why? Prove mathematically

352) Two metals X and Y, when illuminated with appropriate radiation, emit photoelectrons. The work function of X is higher than of Y. Which metal will have higher value of threshold frequency?

353) If the frequency of incident radiation is equal to the threshold frequency, what will be the value of stopping potential?

354) All the photoelectrons are not emitted with same energy. The energies of photoelectrons are distributed over a certain range. Why?

355) Draw graphs showing variation of photoelectric current with applied voltage for two incident radiations of equal frequency and different intensities. Mark the graph for the radiation of higher intensity.

356) If light of wavelength 412.5 nm is incident on each of the metals given below, which ones will show photoelectric emission and why?

Metal	Work Function (eV)
Na	1.92
K	2.15
Ca	3.20
Mo	4.17

357) The maximum kinetic energy of photoelectrons emitted from a surface, when photons of energy 6 eV fall on it is 4 eV. What is the stopping potential (in volt) for the fastest photoelectrons.

358) Aluminium and calcium have photoelectric work functions of ϕ_{Al} = 4.28 eV and ϕ_{ca} = 2.87 eV, respectively.
(i) Which metal requires higher frequency light to produce photoelectrons? Explain.
(ii) Find out the minimum frequency that will produce photoelectrons from each surface.

359) What is the energy associated injoule with a photon of wavelength 4000 $\dot{A}$?

360) How many photons per second does a 100W bulb emit if its efficiency is 10% and wavelength of light emitted is 500 nm?

361) Are the matter waves electromagnetic in nature?

362) Mention the significance of Davisson-Germer experiment.

363) de-Broglie postulated that the relationship, $\lambda = \frac{h}{p}$ is valid for relativistic particles. Find out the de-Broglie wavelength for an (relativistic) electron whose kinetic energy is 3 MeV.

364) Two metals M_1 and M_2 have work functi'ons 2 eV and 4 eV, respectively. Which of the two has a higher threshold wavelength for·photoelectric emission?

365) With what purpose Davisson-Germer experiment for electrons was performed?

366) What are the energies of photons at the
(i) violet and
(ii) red ends of the visible spectrum? The wavelength of light is about 390 nm for violet and about 760 nm for red.

367) The de-Broglie wavelength of a body moving with speed v is λ. On its way, it losses some of its mass and gains twice the speed. Kinetic energy also increases to twice of its initial value. What will be the new value of de-Broglie wavelength?

368) Ultraviolet light of wavelength 200 nm is incident on polished surface of iron. Work function of the surface is 4.71eV. Calculate its stopping potential.

369) Name the phenomenon which shows the quantum nature of electromagnetic radiation.

370) Can non-metals show photoelectric effect?

371) What happens to the wavelength of a photon after it collides with an electron?

372) Show on a graph the variation of the de Broglie wavelength (λ) associated with an electron with the square root of accelerating potential (V).

373) A proton and an alpha particle are accelerated through the same potential. Which one of the two has (i) greater value of de Broglie wavelength associated with it and (ii) less kinetic energy. Give reasons to justify your answer.

374) An electron and a photon have the same de Broglie wavelength. Which one possesses more kinetic energy?

375) Find out work function of the metal, if the kinetic energies of the photoelectrons are E_1 and E_2, with wavelengths of incident light λ_1 and λ_2.

376) An α-particle when accelerated through a potential difference of V volt has a wavelength λ associated with it. In order to have the same wavelength, by what potential difference a proton must be accelerated?

377) The frequency of incident light on a metal surface is doubled. How will this affect the value of K.E. of emitted photoelectrons?

378) An electron and alpha particle have the same kinetic energy. How are the de Broglie wavelength associated with them related?

379) Two metals A and B have work functions 2 eV and 5 eV respectively. Which metal has lower threshold wavelength?

380) Show graphically how the maximum kinetic energy of electrons emitted from a photosensitive surface varies with the frequency of incident radiations.

381) What is the charge on metal in the photoelectric experiment?

382) What is the rest mass of a photon?

383) An electron and proton have the same kinetic energy. Which of the two will have-larger de Broglie wavelength? Give reason.

384) Define the term threshold frequency, in the context of photoelectric emission.

385) Define the term intensity in photon picture of electromagnetic radiation.

3 Marks 141 x 3 = 423

386) What is the de Broglie wavelength associated with
(a) an electron moving with a speed of 5.4 x 10^6m/s
(b)a ball of mass 150g travelling at 30.0m/s?

387) The threshold frequency for a certain metal is $3 * 10^{14}$ Hz.If light of frequency $8.2 * 10^{14}$ Hz is incident on the metal,predict the cut-off voltage for the photoelectric emission

388) The work function for a certain metal is 4.2 ev .Will this metal give photoelectric emission for incident radiation of wavelength 330 nm?

389) The work function of caesium is 2.14 eV. Find
(a) the threshold frequency for caesium and
(b) wavelength of the incident light if the photocurrent is brought to zero by a stopping potential of 0.60 V

390) Monochromatic light of frequency $6.0 \times 10^{14} Hz$ is produced by a laser.The power emitted is $2.0 \times 10^{-3} W$.
(a) What is the energy of a photon in the light beam?
(b) How many photons per second, on the average, are emitted by the source?
Given $h = 6.63 \times 10^{-34} Js$

391) The photoelectric cut-off voltage in a certain experiment is 1.5V. What is the maximum kinetic energy of photoelectrons emitted?

392) In an experiment on photoelectric effect, the slope of the cut off voltage versus frequency of incident light is found to be $4.12 \times 10^{-15} V - s$. Calculate the value of Plank's constant.

393) The threshold frequency of a certain metal is $3.3 \times 10^{14} Hz$. If light of frquency $8.2 \times 10^{14} Hz$ is incident on the metal, predict the cut off voltage for photoelectric emission.

394) The work function of caesium metal is 2.14 eV. When light of frequency 6 x 10^{14} Hz is incident on the metal surface photoemission of electrons occurs. What is the
(a)Maximum kinetic energy of the emitted electrons.
(b)stopping potential and
(c)maximum speed of the emitted photo-electrons?

395) Monochromatic light of wavelength 632.8 nm is produced by a helium-neon laser. The power emitted is 9.42 mW.
(a) Find the energy and momentum of each photon in the light beam.
(b) How many photons per second on the average arrive at a target irradiated by this beam? (Assume the beam to have uniform cross-section which is less than the target area) and
(c) How fast does a hydrogen atom have to travel in order to have the same momentum as that of the photon?

396) The wavelength of light from the spectral emission line of sodium is 589 nm. Find the kinetic energy at which
(a) an electron and
(b) a neutron would have the same de Broglie wavelength.

397) (a) For what kinetic energy of a neutron will the associated de Broglie wavelength be 1.40 x 10^{-10}m?
(b) Also find the de Broglie wavelength of a neutron in thermal equilibrium with matter having an average kinetic energy of 3/2 kT at 300K.

398) (i)An electron beam passes through a region of crossed electric and magnetic fields of intensities E and B respectively. For what value of electron speed will the beam remain undeflected?
(ii)A beam of α -particle and of protons of the same velocity v, enters a uniform magnetic field at right angles to the field lines. The particles describe circular paths . Calculate the ratio of the two paths.

399) Define the term:
(a) (i)Work function
(ii) threshold frequency and
(iii) stopping potential with reference to photoelectric effect
(b) Calculate the maximum kinetic energy of electrons emitted from a photosensitive surface of work function 3.2 eV for the incident radiation of wavelength 300 nm.

400) The energy flux of sunlight reaching the surface of the earth is $1.388 \times 10^3 w/m^2$. How many photons (nearly) per square metre are incident on the Earth per second? Assume that the photons in the sunlight have an average wavelength of 550 nm.

401) A 100 w sodium lamp radiates energy uniformly in all directions. The lamp is located at the centre of a large sphere that absorbs all the sodium light which is incident on it. The wavelength of the sodium light is 589 nm.?
(a) What is the energy per photon associated with the sodium light?
(b) At what rate are the photons delivered to the sphere?

402) Light of frequency 7.21×10^{14} Hz is incident on a metal surface. Electrons with a maximum speed of 6 $\times$ 10^5 m/s are ejected from the surface. What is the threshold frequency for photoemission of electrons?

403) What is the de-Broglie wavelength of a nitrogen molecule is moving with the root-mean-square speed of molecules at this temperature. (Atomic mass of nitrogen = 14.0076 u)

404) (a)An x-ray tube produces a continuous spectrum of radiation with its short wavelength end at 0.45 A. What is the maximum energy of a photon in the radiation?
(b) Form your answer to(a), guess what order of accelerating voltage (for electrons) is required in such a tube?

405) The wavelength of a photon needed to remove a proton from a nucleus which is bound to the nucleus with 1 MeV energy is nearly
(a) 1.2 nm
(b) 1.2 x 10^{-3} nm
(c) 1.2 x 10^{-6} nm
(d) 1.2 x 10^{1} nm

406) An electron (mass m) with an initial velocity $v = v_0\vec{i}$ is in an electric field $E = E_0\vec{j}E = E_0\vec{j}$. If $\lambda = \frac{h}{mv_0}$ its de-Broglie wavelength at time t is given by (a)λ_0
(b) $\lambda_0\sqrt{1 + \frac{e^2E_0^2 \quad t^2}{m^2v_0^2}}$
(c)$\frac{\lambda_0}{\sqrt{1+\frac{e^2E^2t^2}{m^2v_0^2}}}$
(d)$\frac{\lambda_0}{\sqrt{1+\frac{e^2E^2t^2}{m^2v_0^2}}}$

407) Two particles A and B of de-Broglie wavelength $\lambda_1 \; and \; \lambda_2$ combine to form a particle C. The process conserves momentum. Find the de-Broglie wavelength of the particle C.(The motion is one dimensional).

408) An electron, an α - particle and a photon have the same kinetic energy. Which of these particles has the largest de-Broglie wavelength?

409) Write the basic features of photon pictures of electromagnetic radiation on which Einstein's photoelectric equation is based.

410) When the light of wavelength 400nm is incident on the cathode of a photocell, the stopping potential recorded is 6V. If the wavelength of the incident light is increased to 600nm, calculate the new stopping potential.

411) The electric field associated with a monochromatic beam of light becomes zero, 2.4×10^{15} times per second. Find the maximum kinetic energy of the photoelectrons when this light falls on a metal surface whose work function is 2.0eV, h=$6.63 \times 10^{-34} Js$

412) Ultra-violet of wavelength and$800\mathring{A} \quad 700\mathring{A}$ when allowed to fall on hydrogen atoms in their ground state is found to liberate electrons with K.E 1.8eV and 4.0 eV respectively. Find the value of Planck's constant.

413) Light of wavelength falls $2000\mathring{A}$ on an aluminum surface. In aluminum, 4.2eV are required to remove an electron. What is the kinetic energy of
(a) the fastest
(b) the slowest emitted photoelectrons,
(c) what is the stopping potential?
(d) What is the cutoff wavelength for aluminum? Planck's constant h = $6.6 \times 10^{-34} Js.$ and speed of light. c = 3×10^8

414) Find the frequency of light, which ejects electrons from a metal surface fully stopped by retarding potential of 3V. The photoelectric effect begins in this metal at a frequency of $6 \times 10^{14} s^{-1}$ Find the work function of this metal.

415) The work function for cesium is 1.8eV. Light of $4500\mathring{A}$ is incident on it. Calculate
(i) the maximum kinetic energy of the emitted photoelectron
(ii) maximum velocity of the emitted photoelectron
(iii) if the intensity of the incident light is doubled, then find the maximum kinetic energy of the emitted photoelectron
Given $h = 6.6 \times 10^{-34} Js,\ m_e = 9.1 \times 10^{-31} kg,\ c = 3 \times 10^8 ms^{-1}$

416) Find the difference of kinetic energies of photoelectrons emitted from a surface by light of wavelengths $2500\mathring{A} and\ 5000\mathring{A}$

417) The electric field associated with a light wave is given by $E = E_0 sin\left[(1.57 \times 10^7 m^{-1})(ct - x)\right]$
Find the stopping potential when this light is used in an experiment on photoelectric effect with the emitter having work function 2.1eV.

418) A photon of wavelength $3310\mathring{A}$ falls on a photocathode and an electron of energy 3×10^{-19} J is ejected. If the wavelength of the incident photon is changed to $5000\mathring{A}$, the energy of the ejected electron is 9.72×10^{-20} J. Calculate the value of Planck's constant and threshold wavelength of the photon.

419) Radiation of wavelength 180 nm ejects photoelectrons from a plate whose work function is 2.0eV. If a uniform magnetic field of flux density $5.0 \times 10^{-5} T$ is applied to the plate, what should be the radius of the path followed by electrons ejected normally from the plate with maximum energy?

420) The maximum velocities of the photoelectrons ejected are v and 2v for incident light of wavelength 400nm and 250 nm on a metal surface respectively. Calculate the work function of the metal

421) A radio transmitter operates at a frequency of 880k Hz and a power of 10kW. Find the number of photons emitted per second.
$h = 6.6 \times 10^{-34} Js$

422) The minimum light intensity that can be perceived by the eye is about $10^{-10} Wm^{-2}$ Find the number of photons of wavelength $5.84 \times 10^{-7} m$ that must enter the pupil, of area $10^{-4} m^2 s^{-1}$ for vision.

423) Find the number of photons emitted per minute by a 25W source of monochromatic light of wavelength $5000\mathring{A}$
Given $h = 6.6 \times 10^{-34} Js$

424) Monochromatic light of frequency is$5.0 \times 10^{14} Hz$ produced by a laser. The power emitted is $3.0 \times 10^{-3} W$ Estimate the number of photons emitted per second on an average by the source.

425) A parallel beam of light is incident normally on a plane surface absorbing 40% of the light and reflecting the rest. If the incident beam carries 10 watts of power, find the force exerted by it on the surface.

426) Find the number of photons emitted per second by a 40W source of monochromatic light of wavelength 6000$\mathring{A}$. What is the photoelectric current assuming 5% efficiency of photoelectric effect?

427) The de-Broglie wavelength associated with a material particle when it is accelerated through a potential difference of 150 V is $1\mathring{A}$ What will be the de-Broglie wavelength associated with the same particle when it is accelerated through a potential difference of 1350 V?

428) An electron is accelerated through a potential difference of 64 volts. What is the de-Broglie wavelength associated with it? To which part of the electromagnetic spectrum does this value of wavelength correspond?

429) A neutron is an uncharged particle of mass $1.67 \times 10^{-27} kg$ Calculate the de-Broglie wavelength of the neutron moving with a velocity, such that K.E. is 0.04eV, $h = 6.6 \times 10^{-34} Js$

430) Calculate the de-Broglie wavelength of an electron of kinetic energy 100 eV. Given $m_e = 9.1 \times 10^{-31} kg, h = 6.6 \times 10^{-34} Js$

431) The de-Broglie wavelength of an electron moving with a velocity $1.5 \times 10^8 ms^{-1}$ is equal to that of a photon. Calculate the ratio of the kinetic energy of the electron to that of photon

432) Calculate the energy of an electron having de-Broglie wavelength $5500\mathring{A}$
$Given\ h = 6.6 \times 10^{-34} Js,\ m_e = 9.1 \times 10^{-31} kg$

433) An electron and a photon each have a wavelength 2nm. Find (i) their momenta (ii) the energy of a photon and (iii) the kinetic energy of electron. $Given\ h = 6.6 \times 10^{-34} Js$

434) An $\alpha - particle$ and a proton are accelerated from rest through the same potential difference V. Find the ratio of de-Broglie wavelength associated with them.

435) The wavelength of a photon is $1.4\mathring{A}$ .It collides with an electron. Its wavelength after collision is $4\mathring{A}$. Calaculate the energy of scattered electron.

436) Find the energy that should be added to an electron of energy 2eV to reduce its de-Broglie wavelength from 1nm to 0.5nm.

437) The de-Broglie wavelength associated with proton changes by 0.25% If its momentum is changed by, 9×10^{-26} find the initial momentum of the electron.

438) Find the de-Broglie wavelength associated with a proton moving with a velocity 0.5c, where $c = 3 \times 10^8 m/s, rest\ mass\ of\ proton = 1.67 \times 10^{-27} kg,\ h = 6.6 \times 10^{-34} Js.$

439) Find the de-Broglie wavelength of an electron in a metal at $127^{\circ}C$ and compare it with the mean separation between two electrons in a metal which is about. $2\mathring{A}$ Given $h = 6.6 \times 10^{-34} Js$,
$m_e = 9.1 \times 10^{-31} kg. Boltzmann\ constant\ k = 1.38 \times 10^{-23} JK^{-1}$

440) Given that a photon of light of wavelength has$10000\mathring{A}$ an energy equal to 1.23eV. When the light of wavelength $5000\mathring{A}$ and intensity I_0 falls on a photoelectric cell and the saturation current is ampere0.40×10^{-6} and the stopping potential is 1.36 volt, made, then (i) what is the work function? (ii) If the intensity of made,$4I_0$ what should be the saturation current and stopping potential?

441) The maximum kinetic energy of photoelectrons emitted from a metal surface is 30eV when the monochromatic light of wavelength fallsλ on it. When the same surface is illuminated with light of wavelength,2λ the maximum kinetic energy of photoelectrons is observed to be 10eV. Calculate the wavelength λ and determine the maximum wavelength of incident radiation for which photoelectrons can be emitted by this surface.
$h = 6.6 \times 10^{-34} Js.$

442) 10.6eV photons of intensity $2.0W/m^2$ fall on a platinum surface of the area $1.0 \times 10^{-4} m^2$ and work function 5.6eV, 0.53% of the incident photons eject photoelectrons. Find the number of photoelectrons emitted per second and their minimum and maximum energies

443) When a surface is irradiated with light of wavelength $4950\mathring{A}$, a photocurrent appears which vanishes if a retarding potential greater than 0.6 volts is applied across the photo-tube. When a different source of light is used, it is found that the critical retarding potential is changed to 1.1volt. Find the work function of the emitting surface and the wavelength of the second source. If the photoelectrons are subjected to a magnetic field of 10 teslas, what changes will be observed in the above two retarding potentials?

444) What amount of energy should be added to an electron to reduce its de-Broglie wavelength from 100 to 50 pm? Given, $h = 6.6 \times 10^{-34} Js, m_e = 9.1 \times 10^{-31} kg.$

445) The activity of a radioactive sample falls from $600s^{-1} to 500s^{-1}$ in 40 minutes. Calculate its half-life.

446) A radioactive nucleus can decay by two different processes. The half-life for the first process is t_1 and that for the second process is t_2 Show that and that effective half-life t of the nucleus is given by $\frac{1}{t} = \frac{1}{t_1} + \frac{1}{t_2}$

447) Calculate packing fraction of $\alpha - particle$ from the following data:
$m_\alpha = 4.0028 a.m.u$
$m_p = 1.00758 a.m.u.$
$m_n = 1.00897 a.m.u.$

448) The binding energies per nucleon for deuteron and helium are 1.1 MeV and 7.0 MeV respectively. What would be the energy released when two deuterons fuse to form a helium nucleus?

449) M1 and M2 represent the masses of $_{10}Ne^{20}$ nucleus and $_{20}Ca^{40}$ nucleus respectively. State whether M2=2M1 or M2 > 2M1 or M2< 2M1

450) Calculate the energy of the following nuclear reaction:
$_1H^2 +_1 H^3 \rightarrow_2 He^4 +_0 n^1 + Q$
$Given\ m(_1H^2) = 2.014102\ u$
$m(_1H^3) = 3.016049\ u$
$m(_2He^4) = 4.002603\ u$
$m(_0n^1) = 1.008665\ u$

451) A particle is moving three times as fast as an electron. The ratio of the de-Broglie wavelength of the particle to that of the electron is 1.813 x 10^{-4}. Calculate the particle's mass and identify the particle.

452) The energy flux of sunlight reaching the surface of the earth is$1.388 \times 10^3 W/m^2$. How many photons (nearly) per square metre are incident on the earth per second? Assume that the photons in the sunlight have an average wavelength of 550nm.

453) What is the de-Broglie wavelength of
(a) a bullet of mass 0.040 kg travelling at the speed of 1.0 km/s?
(b) a ball of mass 0.060 kg moving at a speed of 1.0 m/s?
(c) a dust particle of mass $1.0 \times 10^{-9} kg$ drifting with a speed of 2.2 m/s?

454) An electron and a photon each have a wavelength of 1.00nm.Find
(a) their momenta
(b) the energy of the photon and
(c) the kinetic energy of electron.
$h = 6.63 \times 10^{-34} Js; m_e = 9.1 \times 10^{-31} kg$

455) (a) For what kinetic energy of a neutron will the associated de-Broglie wavelength be $1.40 \times 10^{-10} m$?
(b) Also find the de-Broglie wavelength of a neutron, in thermal equilibrium with matter, having an average kinetic energy of 3/2kT at 300K.
Given, $h = 6.63 \times 10^{-34} Js; m_n = 1.675 \times 10^{-27} kg; k = 1.38 \times 10^{-23} JK^{-1}$

456) In an accelerator experiment on high-energy collisions of electrons with positions, a certain event is interpreted as annhilation of an electron-position pair of total energy 10.2 Bev into two γ-rays of equal energy. What is the wavelength associated with γ rays?$(1 BeV = 10^9 eV)$

457) The work functions for the following metal are given, Na = 2.75 eV, K = 2.30 eV, Mo = 4.17 eV, Ni = 5.15 eV. Which of these metals will not give photoelectric emission for a radiation of wavelength 3300$\overset{\circ}{A}$ from a He-Cd laser placed 1m away from the photocell? What happens if the laser is brought nearer and placed 50 cm away?

458) A small metal plate of work function ϕ is kept at a distance r from a singly ionised, fixed ion. A monochromit light beam is incident on the metal plate and photoelectrons are emitted. Find maximum wavelength of the light beam so that some of the electrons may go round the ion along a circle.

459) The fringe width in a young's doubt slit experiment is mm, distance between slit and screen is 1.2m and separation between the slits is 0.24mm. The radiation of same source is incident on a photo-cathode of work function 2.2 eV. Find the stopping potential.

460) A good quality mirror reflects about 75% of light incident on it. How will you find out, whether 25% of the photons have not been reflected at all or all the photons have been reflected but energy of each has been reduced by 25%?

461) It is not possible for a photon to be completely absorbed by a free electron. Explain.

462) A beam of white light is incident normally on a plane surface absorbing 70% of the light and reflecting the rest. If the incident beam of light is of power P, find the force exerted by it on the surface.

463) Explain why the saturation current in photoelectric effect experiment with a light of one frequency and intensity is independent of the anode potential.

464) Find the de Broglie wavelength associated with an electron moving with velocity 0.6c. Given, rest mass of electron = $9.1 \times 10^{-31} kg$,$h = 6.63 \times 10^{-34} Js$

465) The work functio of caesium is 2.14 eV. calculate
(i) the threshold frequency for caesium and
(ii) the wavelength of the incident light, if the photocurrent is brought to zero by a stopping potential of 0.60 V.
Given, h = 6.63 x 10^{-34} J^{-s}.

466) If h is Planck's constant, find the momentum of a wavelength 0.4$\AA$

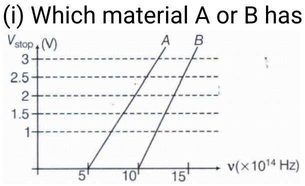
467) An electron, α -particle and a proton have the same de-Broglie wavelengths. Which of theseparticle has
(i) minimum kinetic energy?
(ii) maximum kinetic energy and why?
In what way has the wave nature of electron beam exploited in an electron microscope?

468) (i) Write the important properties of photons which are used to establish Einstein's photoelectric equation.
(ii) Use this equation to explain the concept of
(a) threshold frequency and
(b) stopping potential.

469) An electron and a photon each have a wavelength 1.00 nm. Calculate
(i) their momenta,
(ii) the energy of the photon and
(iii) the kinetic energy of the electron.

470) The momentum of photon of electromagnetic radiation is $3.3 \times 10^{-29}\ kg - ms^{-1}$ Find out the frequency and wavelength of the wave associated with it.

471) A student performs an experiment on photoelectric effect, using two materials A and B. A plot of V_{stop} versus v is given in the figure.
(i) Which material A or B has a higher work function?



(ii) Given the electric charge of an electron =$1.6 \times 10^{-19} C$, find the value of h obtained from the experiment for both A and B.
Comment on whether it is consistent with the Einstein's theory.

472) A proton and an electron have same de-Broglie Wavelength. Which of them moves fast and which possesses more kinetic energy? Justify your answer.

473) Find de-Broglie wavelength of neutron at 127^0 mass of neutron = 1.66 x 10^{-27} kg Boltzmann constant k = 1.38 x 10^{-23} j mol^{-1} K^{-1} and planck' constant h = 6.63 x 10^{-34} J-s

474) Write Einstein's photoelectric equation and mention which important features in photoelectric effect can be explained with the help of this equation. The maximum kinetic energy of the photoelectrons gets doubled when the wavelength of light incident on the surface changes from $\lambda_1\ to\ \lambda_2$. Derive the expressions for the threshold wavelength λ_0 and work function for the metal surface.

475) Determine the de-Broglie wavelength associated with an electron,accelerated through a potential difference of 100 v

476) (i) Describe briefly three experimentally observed features in the phenomenon of photoelectric effect.
(ii) Discuss briefly how wave theory of light cannot explain these features.

477) (i) Determine the de-Broglie wavelength of a proton whose kinetic energy is equal to the rest mass energy of an electron. Mass of proton is 1836 times that of electron.
(ii) In which region of electromagnetic spectrum does this wavelength lie?

478) Which two main observations in photo-electricity led Einstein to suggest the photon theory for the interaction of light with the free electrons in a metal? Obtain an expression for the threshold frequency for photoelectric emission in terms of the work function of the metal.

479) The data given below gives the photon energy (in eV) for a number of waves whose wavelength values (in nm) are also given.

Wavelength (in nm)	200	400	600	800	1000	1200
Photon Energy (in eV)	6.216	3.108	2.072	1.554	1.243	1.036

(without doing any calculation/taking any reading), explain how one can use this data to draw an appropriate graph to infer
(a) Photon energy corresponding to a wavelength of 100 nm.
(b) the wavelength value (in nm) corresponding to a photon energy of 1 eV.
(c) velocity of light, assuming that the value of plank's constant is known.

480) (a) The mass of a particle moving with velocity 5 x 10^6 ms^{-1} has de-Broglie wavelength associated with it to be 0.135 nm. Calculate its mass.
(b) In which region of the electromagnetic spectrum does this wavelength lie?

481) In which region of the electromagnetic spectrum does this wavelength lie?

482) Plot a graph showing the variation of stopping potential with the frequency of incident radiation for two different photosensitive materials having work functions W_{01} and W_{02} ($W_{01} > W_{02}$). On what' factors does the
(i) slope and
(ii) intercept of the lines depend ?

483) Define the terms (i) cut-off voltage' and (ii) threshold frequency' in relation to the phenomenon of photoelectric effect. Using Einstein's photoelectric equation show how the cut-off voltage and threshold frequency for a given photosensitive material can be determined with the help of a suitable plot/graph.

484) Draw a plot showing the variation of potoelectric current with collector plate potential for two different frequencies, $v_1 > v_2$ of incident radiation having the same intensity. In which case will the stopping potential be hgiher ? Justify your answer.

485) (a) Describe briefly how Davisson - Germer experiment demonstrated the wave nature of electrons.
(b) An electron is accelerated from rest through a potential V. Obtain the expression for the de- Broglie wavelength associated with it.

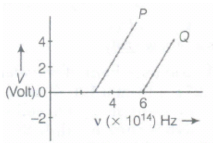
486) Student may write the following explanation df the experiment using the diagram given in main section.

487) In Davisson and Germer experiment, state the observations which led to (a) show the wave nature of electrons and (b) confirm the de-Broglie relation.

488) (i) How does one explain the emission of electrons from a photosensitive surface with the help of Einstein's photoelectric equation?
(ii) The work function of the following metals is given as Na = 2.75 eV, K = 2.3eV, MO = 4.17 eV and Ni = 5.15eV. Which of these metals will not cause photoelectric emission for radiation of wavelength 3300 Å from a laser source placed 1 m away from these metals? What happens if the laser source is brought nearer and placed 50 cm away?

489) (i) State two important features of Einstein's photoelectric equation.
(ii) Radiation of frequency 10^{15} Hz is incident on two photosensitive surfaces P and Q. There is no photoemission from surface P. Photoemission occurs from surface Q but photoelectrons have zero kinetic energy. Explain these observations and find the value of work function for surface Q.

490) In the study of a photoelectric effect, the graph between the stopping potential V and frequency v of the incident radiation on two different metals P and Q is shown below.



(i) Which one of the two metals has higher threshold frequency?
(ii) Determine the work function of the metal which has greater value.
(iii) Find the maximum kinetic energy of electron emitted by light of frequency 8 x10^{14} Hz for this metal.

491) Sketch the graphs showing variation of stopping potential with frequency of incident radiations for two photosensitive materials A and B having threshold frequencies v_A > V_B.
(i) In which case is the stopping potential more and why?
(ii) Does the slope of the graph, depend on the nature of the material used? Explain.

492) Define the term "cut-off frequency" in photoelectric emission. The threshold frequency of a metal is f. When the light of frequency 2f is incident on the metal plate, the maximum velocity of photo-electron is v_1. When the frequency of the incident radiation is increased to 5f, the maximum velocity of photoelectrons is v_2. Find the ratio v_1:v_2.

493) Write three characteristic features in photoelectric effect which cannot be explained on the basis of wave theory of light, but can be explained only using Einstein's equation.

494) A beam of monochromatic radiation is incident on a photosensitive surface. Answer the following questions giving reasons.
(a) Do the emitted photoelectrons have the same kinetic energy?
(b) Does the kinetic energy of the emitted electrons depend on the intensity of incident radiation?
(c) On what factors does the number of emitted photoelectrons depend?

495) Draw a graph between the frequency of incident radiation (v) and the maximum kinetic energy of the electrons emitted from the surface of a photosensitive material. State clearly how this graph can be used to determine
(i) Planck's constant and
(ii) work function of the material.

496) Light of wavelength 2000 Å falls on a metal surface of work function 4.2 eV. What is the kinetic energy (in eV) of the fastest electrons emitted from the surface?
(i) What will be the change in the energy of the emitted electrons if the intensity of light with same wavelength is doubled?
(ii) If the same light falls on another surface of work function 6.5 eV, what will be the energy of emitted electrons?

497) Define the terms threshold frequency and stopping potential in the study of photoelectric emission. Explain briefly the reasons why wave theory of light is not able to explain the observed features in photoelectric effect?

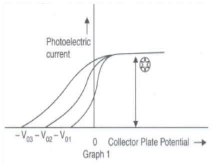
498) (i) Why photoelectric effect cannot be explained on the basis of wave nature of light? Give reasons.
(ii) Write the basic features of photon picture of electromagnetic radiation on which Einstein's photoelectric equation is based.

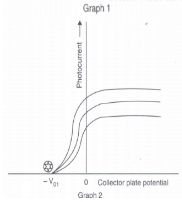
499) An electron and a proton are accelerated through the same potential. Which one of the two has
(i) greater value of de-Broglie wavelength associated with it and
(ii) less momentum?
Justify your answer.

500) Point out two distinct features observed experimentally in photoelectric effect which
cannot be explained on the basis of wave theory of light. State how the photon picture' of light provides an explanation of these features.

501) Write Einstein's photoelectric equation. State clearly how this equation is obtained using the photon picture of electromagnetic radiation. Write the three salient features observed in photo- electric effect which can be explained using this equation.

502) The graphs, drawn here, are for the phenomenon of photoelectric effect.





(i) Identify which of the two characteristics (intensity/frequency) of incident light, is being kept constant in each case.

(ii) Name the quantity, corresponding to the, mark, in each case.

(iii) Justify the existence of a 'threshold frequency' for a given photosensitive surface

503) Predict and Explain:

Light of a particular wavelength does not eject electrons from the surface of a given metal.

(i) Should the wavelength of the light be increased or decreased in order to make ejection of electrons possible?

(ii) Choose the best explanation from among the following:

(a) The energy of a photon is proportional to its frequency, i.e. inversely proportional to its wavelength. To increase the energy of the photons, so they can eject electrons, one must decrease their wavelength.

(b) The photons have too little energy to eject electrons. To increase their energy, their wavelength should be increased.

504) Electrons are emitted from the cathode of a photocell of negligible work function, when photons of wavelength λ are incident on it. Derive the expression for the de-Broglie wavelength of the electrons emitted on terms of the wavelength of the incident light.

505) Explain giving reasons for the following:

(a) Photoelectric current in a photocell increase with the increase in the intensity of the incident radiation.

(b) The stopping potential (V_0) varies linearly with the frequency (v) of the incident radiation for a given photosensitive surface with the slope remaining the same for different surfaces.

(c) Maximum kinetic energy of the photoelectrons is independent of the intensity of incident radiation.

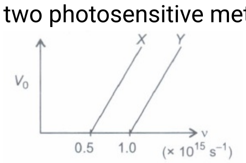
506) Light of intensity I and frequency v incident on a photosensitive surface and causes photoelectric emission. What will be the effect on anode current when

(i) the intensity of light is gradually increased,

(ii) the frequency of incident radiation is increased, and

(iii) the anode potential is increased? In each case, all other factors remain the same. Explain, giving justification in each case.

507) The following graph shows the variation of stopping potential Vo with the frequency v of the incident radiation for two photosensitive metals X and Y:



(i) Which of the metals has larger threshold wavelength? Give reason.

(ii) Explain, giving reason, which metal gives out electrons, having larger kinetic energy, for the same wavelength of the incident radiation.

(iii) If the distance between the light source and metal Xis halved, how will the kinetic energy of electrons emitted from it change? Give reason.

508) Define the term 'work function' of a metal. The threshold frequency of a metal is v_0 When the light of frequency $2v_0$ is incident on the metal plate, the maximum velocity of electrons emitted is v_1 When the frequency of the incident radiation is increased to $5v_0$ the maximum velocity of electrons emitted is v_2 Find the ratio of v_1 to v_2.

509) A proton and deuteron are accelerated through the same accelerating potential. Which one of the two has
(a) greater value of de Broglie wavelength associated with it, and
(b) less momentum?
Give reasons to justify your answer.

510) Write Einstein's photoelectric equation and point out any two characteristic properties of photons on which this equation is based.
Briefly explain the three observed features which can be explained by this equation.

511) An electromagnetic wave of wavelength λ is incident on a photosensitive surface of negligible work function. If the photo-electrons emitted from this surface have the de Broglie wavelength λ_1 prove that $\lambda = \left(\frac{2mc}{h}\right)\lambda_1^2$.

512) Red light, however bright it is, cannot produce the emission of electrons from a clean zinc surface. But even weak ultraviolet radiation can do so. Why? X-rays of wavelength λ fall on a photosensitive surface, emitting electrons. Assuming that the work function of the surface can be neglected, prove that the de Broglie wavelength of electrons emitted will be $\sqrt{\frac{h\lambda}{2mc}}$.

513) Why are de Broglie waves associated with a moving football not visible? The wavelength, λ of a photon and the de Broglie wavelength of an electron have the same value. Show that the energy of the photon is $\frac{2\lambda mc}{h}$ times the kinetic energy of the election, where m, c, and h have their usual meanings.

514) When radiations of wavelengths 3000 $\overset{\circ}{A}$ and 4000 $\overset{\circ}{A}$ fall on the surface of metals A and B, and the photoelectrons emitted have maximum kinetic energies of 2 eV and 1 eV respectively. Calculate the maximum wavelength of the incident radiation for which there will be photoelectron emission from the same surface.

515) Light of wavelength 2500 $\overset{\circ}{A}$ falls on a metal surface of work function 3.5 eV. What is the kinetic energy (in eV) of (i) the fastest and (ii) the slowest electrons emitted from the surface?
If the same light falls on another surface of work function 5.5. eV, what will be the energy of emitted electrons?

516) The ground state energy of hydrogen atom is - 13.6 eV. The photon emitted during the transition of electron from n = 2 to n = 1 state, is incident on a photosensitive material of unknown work function. The photoelectrons are emitted from the materials with a maximum kinetic energy of 8 eV. Calculate the threshold wavelength of the material used.

517) An electron and a proton, each have de Broglie wavelength of 1.00 nm.
(i) Find the ratio of their momenta.
(ii) Compare the kinetic energy of the proton with that of the electron.

518) A beam of monochromatic radiation is incident on a photosensitive surface. Answer the following questions giving reasons:
(a) Do the emitted photoelectrons have the same kinetic energy?
(b) Does the kinetic energy of the emitted electrons depend on the intensity of incident radiation?
(c) On what factors does the number of emitted photoelectrons depend?

519) In a plot of photoelectric current versus anode potential, how does
(i) the saturation current vary with anode potential for incident radiations of different frequencies but same intensity?
(ii) the stopping potential vary for incident radiations of different intensities but same frequency?
(iii) photoelectric current vary for different intensities but same frequency of incident radiations? Justify your answer in each case.

520) When a surface I ern thick is illuminated with light of wavelength λ, the stopping potential is V_0, but when the same surface is illuminated by light of wavelength 3λ, the stopping potential is $\frac{V_0}{6}$ Find threshold wavelength for metallic surface.

521) Compare the photoelectric effect on the basis of photon theory and wave theory of light and hence explain why the wave theory failed to explain it.

522) There are materials which absorb photons of shorter wavelength and emit photons of longer wavelength. Can there be stable substances which absorb photons of larger wavelength and emit light of shorter wavelength?

523) Two monochromatic beams A and B of equal intensity I, hit a screen. The number of photons hitting the screen by beam A is twice that by beam B, then what inference can you make about their frequencies?

524) (i) Define the terms (a) thresold frequency and (b) stopping potential in photoelectric effect.
(ii) Plot a graph of photocurrent versus anode potential for a radiation of frequency v and intensities I_1 and I_2 ($I_1 < I_2$).

525) What are matter waves ? A proton and an alpha particle are accelerated through the same potential difference. Find the ratio of the de-Broglie wavelength associated with the proton to that with the alpha particle.

526) The threshold frequency for a certain metal is 3.3×10^{14} Hz. If light of frequency 8.2×10^{14} Hz is incident on the metal, predict the cut-off voltage for the photoelectric emission.

Case Study Questions 11 x 4 = 44

527) Photoelectric effect is the phenomenon of emission of electrons from a metal surface, when radiations of suitable frequency fallon them. The emitted electrons are called photoelectrons and the current so produced is called photoelectric current.
(i) With the increase of intensity of incident radiations on photoelectrons emitted by a photo tube, the number of photoelectrons emitted per unit time is

(a) increases **(b) decreases**
(c) remains same **(d) none of these**

(ii) It is observed that photoelectron emission stops at a certain time t after the light source is switched on. The stopping potential (V) can be represented as

(a) $2(KE_{max}/e)$ **(b) (KE_{max}/e)**
(c) $(KE_{max}/3e)$ **(d) $(KE_{max}/2e)$**

(iii) A point source of light of power 3.2×10^{-3} W emits monoenergetic photons of energy 5.0 eV and work function 3.0 eV. The efficiency of photoelectron emission is 1 for every 10^6 incident photons. Assume that photoelectrons are instantaneously swept away after emission. The maximum kinetic energy of photon is

(a) 4 eV **(b) 5 eV**
(c) 2 eV **(d) Zero**

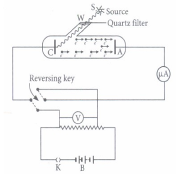
(iv) Which of the following device is the application of Photoelectric effect?

(a) Light emitting diode **(b) Diode**
(c) Photocell **(d) Transistor**

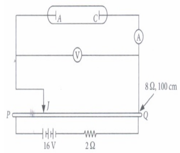
(v) If the frequency of incident light falling on a photosensitive metal is doubled, the kinetic energy of the emitted photoelectron is

(a) unchanged **(b) halved**
(c) doubled **(d) more than twice its initial value**

528) When a monochromatic radiations of suitable frequency obtained from source S, after being filtered by a filter attached on the window W, fall on the photosensitive place C, the photo electrons are emitted from C, which get accelerated towards the plate A if it is kept at positive potential. These electrons flow in the outer circuit resulting in photoelectric current. Due to it, the micro ammeter shows a deflection. The reading of micrommeter measures the photoelectric current.



An experimental setup of verification of photoelectric effect is shown in figure. The voltage across the electrodes is measured with the help of an ideal voltmeter, and which can be varied by moving jockey J on the potentiometer wire. The battery used in potentiometer circuit is of 16 V and its internal resistance is 2 Ω The resistance of 100 ern long po.t•e. ntiometer wire is 8 Ω .



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

Light	**Violet**	**blue**	**Green**	**Yellow**	**Orange**	**Red**
λ in $\dot{A}$	4000-5000	4500-5000	5000-5500	5500-6000	6000-6500	6500-7000

(i) When radiation falls on the cathode plate, a current of 2 μ A is recorded in the ammeter. Assuming that the vacuum tube setup follows Ohm's law, the equivalent resistance of vacuum tube operating in the case when jockey is at end P is

(a) 8 x 10^8 Ω (b) 16 x $10^6\Omega$ (c) 8 x 10^6 Ω (d) 10 x $10^6\Omega$

(ii) It is found that ammeter current remains unchanged (2 μ A) even when the jockey is moved from the end P to the middle point of the potentiometer wire. Assuming that all the incident photons eject electrons and the power of the light incident is 4 x $10^{-6}\Omega$ Then, the color of the incident light is

(a) Green (b) Violet (c) Red (d) Orange

(iii) Which of the following colors may not give photoelectric effect for this cathode?

(a) Green (b) Violet (c) Red (d) Orange

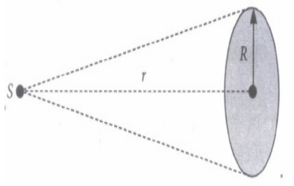
(iv) When other light falls on the anode plate, the ammeter reading zero till jockey is moved from the end P to the middle point of the wire PQ. Therefore, the deflection is recorded in the ammeter. The maximum kinetic energy of the emitted electron is

(a) 16 eV (b) 8 eV (c) 4 eV (d) 10 eV

(v) If the intensity of incident radiation is increased twice, the number of photoelectrons emitted per second will be

(a) halves (b) double (c) remain same (d) four times

529) A point source S of power 6.4×10^{-3}W emits mono energetic photons each of energy 6.0 eV. The source is located at a distance of 0·8 m from the centre of a stationary metallic sphere of work function 3·0 eV and of radius 1.6×10^{-3} m as shown in figure. The sphere is isolated and initially neutral and photoelectrons are instantly taken away from sphere after emission. The efficiency of photoelectric emission is one for very 10^5 incident photons.



(i) The'power received by the sphere through radiations is

(a) $\frac{4R^2}{Pr}$ (b) $\frac{PR^2}{4r^2}$ (c) $\frac{p^2R}{2\pi r}$ (d) $\frac{PR}{4r}$

(ii) Number of photons striking the metal sphere per second is

(a) 6.7×10^9 (b) 3.3×10^9 (c) 6.7×10^{10} (b) 3.3×10^{10}

(iii) The number of photoelectrons emitted per second is about

(a) 3.3×10^4 (b) 6.7×10^4 (c) 6.7×10^{15} (d) 3.3×10^{15}

(iv) The photoelectric emission stops when the sphere acquires a potential about

(a) 2 V (b) 3 V (c) 4 V (d) 6 V

(v) If the distance of source becomes double from the centre of the metal sphere then the power received by the sphere

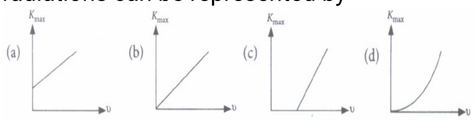
(a) $\frac{PR^2}{4r^2}$ (b) $\frac{PR^2}{16r^2}$ (c) $\frac{PR^2}{4r}$ (d) $\frac{P^2R^2}{16r^2}$

530) According to Einstein, when a photon of light of frequency u or wavelength λ is incident on a photosensitive metal surface of work function ϕ_0w' here ϕ_0< hv (here, h is Planck's constant), then the emission of photoelectrons takes place. The maximum kinetic energy of the emitted photoelectrons is given by K_{max} = hv - ϕ_0. If the frequency of the incident light is V_0 called threshold frequency, the photoelectrons are emitted from metal without any kinetic energy. So $hv_0 = \phi$

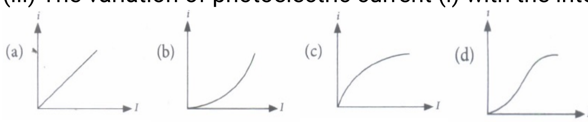
(i) A metal of work function 3·3 eV is illuminated by light of wavelength 300 nm. The maximum kinetic energy of photoelectrons emitted is (taking h = 6·6 x 10^{-34} Js)

(a) 0.413 eV **(b) 0.825 eV** **(c) 1.65 eV** **(d) 1.32 eV**

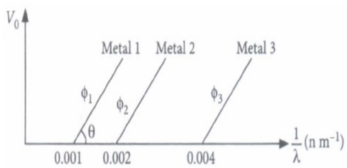
(ii) The variation of maximum kinetic energy (K_{max}) of the emitted photoelectrons with frequency (v) of the incident radiations can be represented by



(iii) The variation of photoelectric current (i) with the intensity of the incident radiation (I) can be represented by

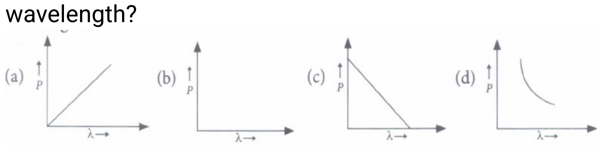


(iv) The graph between the stopping potential (V_0) and $\left(\frac{1}{\lambda}\right)$ is shown in the figure ϕ_1, ϕ_2, ϕ_3 3 are work function. Which of the following options is correct?



(a) $\phi_1 : \phi_2 : \phi_3 = 1 : 2 : 3$
(b) $\phi_1 : \phi_2 : \phi_3 = 4 : 2 : 1$
(c) $\phi_1 : \phi_2 : \phi_3 = 1 : 2 : 4$
(d) Ultraviolet light can be used to emit photoelectrons from metal 2 and metal 3 only

(v) Which of the following figures represent the variation of particle momentum and the associated de- Broglie wavelength?



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

(i) Einstein's photoelectric equation is

(a) $E_{\max} = hv - \phi$ (b) $E = mc^2$ (c) $E^2 = p^2c^2 + m_0^2c^4$ (d) $E = \frac{1}{2}mv^2$

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

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

(iii) When ultraviolet rays incident on metal plate then photoelectric effect does not occur, it occur by incident of

(a) Infrared rays **(b) X-rays** **(c) Radio wave** **(d) Micro wave**

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

(a) n times of the initial kinetic energy

(b) More than n times of the initial kinetic energy

(c) Less than n times of the initial kinetic energy

(d) Kinetic energy of the emitted photoelectrons remains unchanged

(v) A monochromatic light is used in a photoelectric experiment. The stopping potential

(a) Is related to the mean wavelength **(b) Is related to the shortest wavelength**

(c) Is not related to the minimum kinetic energy of emitted photoelectrons **(d) Intensity of incident light**

532) If we allow radiations of a fixed frequency to fall on plate and the accelerating potential difference between the two electrodes is kept fixed, then the photoelectric current is found to increase linearly with the intensity of incident radiation. Here, radiation pressure is P = $\left(\frac{1+e}{C}\right) I$. As, atmosphere pressure at sea level is 10^5Pa. If the intensity of light of a given wavelength, is increased, there is an increase in the number of photons incident on a given area in a given time. But the energy of each photon remain the same.

(i) The number of photons hitting the cone second

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

(ii) A radiation of energy E falls normally on a perfect reflecting surface. The momentum transferred to the surface is

(a) $\frac{E}{c}$ (b) $\frac{2E}{c}$ (c) Ec (d) $\frac{E}{c^2}$

(iii) Which one is correct?

(a) $E^2 = p^2c^2$ (b) $E^2 = p^2c$ (c) $E^2 = p^2$ (d) $E^2 = \frac{p^2}{c^2}$

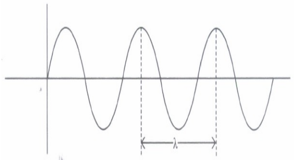
(iv) The incident intensity on a horizontal surface at sea level from the Sun is about 1 k W m^{-2}. Assuming that 50% of this intensity is reflected and 50% is absorbed, determine the radiation pressure on this horizontal surface.

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

(v) Find the ratio of radiation pressure to atmospheric pressure P_0 about 1×10^5 Pa at sea level.

(a) 5×10^{-11} **(b) 4×10^{-8}** **(c) 6×10^{-12}** **(d) 8×10^{-11}**

533) According to de-Broglie, a moving material particle sometimes acts as a wave and sometimes as a particle or a wave associated with moving material particle which controls the particle in every respect. The wave associated with moving particle is called matter wave or de-Broglie wave where wavelength called de-Broglie wavelength is

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

(i) If a proton and an electron have the same de Broglie wavelength, then

(a) kinetic energy of electron < kinetic energy of proton
(b) kinetic energy of electron = kinetic energy of proton
(c) momentum of electron = momentum of proton
(d) momentum of electron < momentum of proton

(ii) Which of these particles having the same kinetic energy has the largest de Broglie wavelength?

(a) Electron **(b) Alpha particle** **(c) Proton** **(d) Neutron**

(iii) Two particles A_1 and A_2 of masses m_1 m_2 ($m_1 > m_2$) have the same de Broglie wavelength. Then

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

(iv) When the velocity of an electron increases, its de Broglie wavelength

(a) increases **(b) decreases** **(c) remains same** **(d) may increase or decrease**

(v) Proton and a-particle have the same de-Broglie wavelength. What is same for both of them?

(a) time period **(b) energy** **(c) frequency** **(d) momentum**

534) According to wave theory, the light of any frequency can emit electrons from metallic surface provided the intensity of light be sufficient to provided necessary energy for emission of electrons, but according to experimental observations, the light of frequency less than threshold frequency can not emit electrons; whatever be the intensity of incident light. Einstein also proposed that electromagnetic radiation is quantised.If photoelectrons are ejected from a surface when light of wavelength λ_1= 550 nm is incident on it. The stopping potential for such electrons is V_s = 0.19 V. Suppose the radiation of wavelength λ_2= 190 nm is incident on the surface.

(i) Photoelectric effect supports quantum nature oflight because

(A) there is a minimum frequency of light below which no photoelectrons are emitted.
(B) the maximum K.E. of photoelectric depends only on the frequency of light and not on its intensity.
(C) even when the metal surface is faintly illuminated, the photo electrons leave the surface immediately.
(D) electric charge of the photoelectrons is quantized.

(a) A,B,C **(b) B,C** **(c) C,D** **(d) A,D,C**

(ii) In photoelectric effect, electrons are ejected from metals, if the incident light has a certain minimum

(a) wavelength **(b) frequency** **(c) amplitude** **(d) angle of incidence**

(iii) Calculate the stopping potential $V_{S2}$of surface.

(a) 4.47 **(b) 3.16** **(c) 2.76** **(d) 5.28**

(iv) Calculate the work function of the surface.

(a) 3.75 **(b) 2.07** **(c) 4.20** **(d) 3.60**

(v) Calculate the threshold frequency for the surface.

(a) 500 x 10^{12} Hz **(b) 480 x 10^{13} Hz** **(c) 520 x 10^{11}Hz** **(d) 460 x 10^{13} Hz**

535) The photon picture of electromagnetic radiations and the characteristic properties of photons are as follows:In the interaction of radiation with matter, radiation behaves as if it is made of particles like photons. Each photon has energy $E(=hv=hc/\lambda)$ and momentum $p\left(=\frac{hv}{c}=\frac{h}{\lambda}\right)$ where h is Planck's constant, v and A are the frequency and wavelength of radiation and c is the velocity of light. The photon energy is independent of the intensity of radiations. All the photons emitted from a source of radiations travel through space with the same speed c. The frequency of photon gives the radiation, a definite energy (or colour) which does not change when photon travels through different media. Photons are not deflected by electric and magnetic fields. This shows that photons are electrically neutral.

(i) Which one among the following shows particle nature of light?

(a) Photoelectric effect **(b) Interference** **(c) Refraction** **(d) Polarization**

(ii) Which of the following statements about photon is incorrect?

(a) Photons exert no pressure **(b) Momentum of photon is** $\frac{hv}{c}$

(c) Rest mass of photon is zero **(d) Energy of photon is hv**

(iii) The rest mass of photon is

(a) $\frac{hv}{c}$ (b) $\frac{hv}{c^2}$ (c) $\frac{hv}{\lambda}$ **(d) zero**

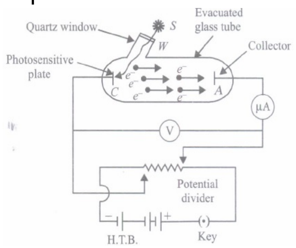
(iv) In a photon-particle collision (such as photon-electron collision), which of the following may not be conserved?

(a) Total energy **(b) Number of photons** **(c) Total momentum** **(d) Both (a) and (b)**

(v) 'n' photons of wavelengt 'λ' are absorbed by a black body of mass 'm'. The momentum gained by the body is

(a) $\frac{h}{m\lambda}$ (b) $\frac{mnh}{\lambda}$ (c) $\frac{nh}{m\lambda}$ (d) $\frac{nh}{\lambda}$

536) To study photoelectric effect, an emitting electrode C of a photosensitive material is kept at negative potential and collecting electrode A is kept at positive potential in an evacuated tube. When light of sufficiently high frequency falls on emitting electrode, photoelectrons are emitted which travel directly to collecting electrode and hence an electric cusrent called photoelectric current starts flowing in the circuit, which is directly proportional to the number of photoelectrons emitted by emitting electrode C.



While demonstrating the existence of electromagnetic waves, Hertz found that high voltage sparks passed across the metal electrodes of the detector loop more easily when the cathode was illuminated by ultraviolet light from an arc lamp. The ultraviolet light falling on the metal surface caused the emission of negatively charged particles,which are now known to be electrons, into the surrounding space and hence enhanced the high voltage sparks.

(i) Cathode rays were discovered by

(a) Maxwell Clerk James **(b) Heinrich Hertz**
(c) William Crookes **(d) J. J. Thomson**

(ii) Cathode rays consists of

(a) photons **(b) electrons** **(c) pistons** **(d) a-particles.**

(iii) Who discovered the charge on an electron for the frist time?

(a) Millikan **(b) Thomson** **(c) Kelvin** **(d) Coulomb**

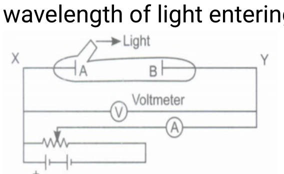
(iv) The dual nature of light is exhibited by

(a) diffraction and photoelectric effect **(b) photoelectric effect**
(c) refraction and interference **(d) diffraction and reflection**

(v) In the phenomenon of electric discharge through gases at low pressure, the coloured glow in the tube appears as a result of

(a) collisions between the charged particles emitted from the cathode and the atoms of the gas
(b) collision between different electrons of the atoms of the gas
(c) excitation of electrons in the atoms
(d) collision between the atoms of the gas.

537) In the investigation of "Photoelectric effect", light is incident on electrode A. This electrode A, along with electrode B is placed inside a vacuum tube diode. These electrodes are made from same metal and are connected to a microammeter and a variable voltage supply. Light enters vacuum tube through a window. With the help of filters, wavelength of light entering the window can be changed.



The data has been obtained from such an experiment

Wavelength (nm)	589	552	330	285
P.D (V)	-0.246	-0.367	-1.870	-2.463

(i) Why must negative potential be applied to electrode B to stop the flow of electrical current?
(ii) Plot a suitable graph to determine Planck's constant h and the minimum energy ϕ in S.I. units.

5 Marks 76 x 5 = 380

538) What is the de-Broglie wavelength of
(a) a bullet of mass 0.040 kg travelling at the speed of 1.0 km/s
(b) a ball of mass 0.060 kg moving at a speed of 1.0 m/s and
(c) a dust particle of mass 1.0 x 10^{-9} kg drifting with a speed of 2.2 m/s?

539) Find the
(a) maximum frequency and
(b) minimum wavelength of X-rays produced by 30 kv electrons.

540) The work function of caesium metal is 2.14eV. When light of frequency $6 \times 10^{14} Hz$ is incident on the metal surface, photoemission of electrons occurs. What is the
(a) maximum kinetic energy of the emitted electrons.
(b) stopping potential and
(c) maximum speed of the emitted photoelectrons..

541) Monochromatic light of wavelength 632.8 nm is produced by a helium-neon laser. The power emitted is 9.42mW.
(a) Find the energy and momentum of each photon in the light beam.
(b) How many photons per second, on the average, arrive at a target irradiated by this beam? (Assume the beam to have uniform cross-section which is less than the target area).
(c) How fast does a hydrogen atom have to travel in order to have the same momentum as that of the photon.

542) The work function for a certain metal is 4.2 eV. Will this metal give photoelectric emission for incident radiation of wavelength 330nm?

543) Light of frequency $7.21 \times 10^{21} Hz$ is incident ona metal surface. Electrons with a maximum speed of $6.0 \times 10^{5} ms^{-1}$ are ejected from the surface. What is the threshold frequency for photoemission of electrons?

544) Light of wavelength 488 nm is produced by an argon laser which is used in the photoelectric effect. When light from this spectral line is incident on the cathode, the stopping potential of photoelectrons is 0.38eV .Find the work function of the material from which the cathode is made.

545) Show that the wavelength of electromagnetic radiation is equal to the de-Broglie wavelength of its quantum (photon)

546) A mercury lamp is a convenient source for studying frequency dependence of photoelectric emission, since it gives a number of spectral lines ranging from the UV to the red end of the visible spectrum. In our experiment with rubidium photocell, the following lines from a mercury source were used:
$\lambda_1 = 3650A^o, \lambda_2 = 4047A^o, \lambda_3 = 4358A^o$ $\lambda_4 = 5461A^0, \lambda_5 = 6907A^o$
The stopping voltages, respectively, were measured to be: V_{01} = 1.28V, V_{02} = 0.95V, V_{03} = 0.74V, V_{04} = 0.16V, V_{05} = 0V
Determine the value of Planck's constant h, the threshold frequency and work function for the material.

547) An electron microscope uses electrons accelerated by a voltage of 50 kV. Determine the de Broglie wavelength associated with the electrons. If other factors (such as numerical aperture etc)are taken to be roughly the same how does the resolving power of an electron microscope compare with that o an optical microscope which uses yellow light?

548) An Electron gun with its collector at a potential of 100 V fires out electrons in a spherical bulb containing hydrogen gas at low pressure (-10^2 mm of Hg).A magnetic field of 2.83 x 10^{-4} T curves the path of the electrons in a circular orbit of radius 12.0 cm. Determine e/m from the data.

549) In an accelerator experiment on high energy collisions of electrons with positrons, a certain event is interpreted as annihilation of an electron-positron pair of total energy 10.2 BeV into two γ -rays of equal energy. What is the wavelength associated with each γ-ray?(1 BeV = 10^9 eV).

550) Estimating the following two numbers should be interesting. The first number will tell you why radio engineers do not need to worry much about photons. The second number tells you why our eye can never count photons,even in barely detectable light.
(a) The number of photons emitted per second by an MW transmitter of 10 kW power emitting radio waves of wavelength 500 m.
(b) The number of photons entering the pupil of our eye per second corresponding to the minimum intensity of while light that we humans can perceive ($\sim (10^{-10} Wm^{-2})$. Take the area of the pupil to be white light to be about 0.4 cm^2 and the average frequency of white light to be about 6 x 10^{14} Hz.

551) Monochromatic radiation of wavelength 640.2 nm (1 nm = 10^{-9} m) from a neon lamp irradiates a photosensitive material made of caesium or tungsten. The stopping voltage is measured to be 0.54 V. The source is replaced by an iron source and its 427.2 nm line irradiates the same photocell. Predict the new stopping voltage.

552) The work function for the following metals is given Na : 2.75 V; K : 230 eV, Mo : 4.17eV; Ni : 5.15 eV

Which of the following metals will not give photoelectron emission for a radiation of wavelength 3300 $\overset{\circ}{A}$ from a $H_e - CI$ laser placed 1 m away from the photocell? What happens if the laser is brought nearer and placed 50 cm away?

553) Light of intensity $10^5 Wm^{-2}$ falls on a sodium photocell of surface area 2.cm^2 Assuming that the stop 5 layers of sodium absorb the incident energy, estimate the time required for photoelectric emission on the wave picture of radiation. The work function for the metal is given to be about 2eV. What is the implication of your answer?

554) Crystal diffraction experiments can be performed using X-rays, or electrons accelerated through appropriate voltage.Which probe has greater energy? (For quantitative comparison,take the wavelength of the probe equal to 1 $\overset{\circ}{A}$, which is of the order of inter-atomic spacing in the lattice), $(m_e = 9.11 \times 10^{-31} kg.)$

555) (a) Obtain the de-Broglie wavelength of a neutron of kinetic energy 150 eV. As you have seen in Q.No.11.31, an electron beam of this energy is suitable for crystal diffraction experiments. Would a neutron beam of the same energy be equally suitable? Explain ($m_n = 1.675 \times 10^{-27}$ kg).
(b)Obtain the de-Broglie wavelength associated with thermal neutrons at room temperature (27°)
(c) Hence explain why a fast neutron beam needs to be thermalized with the environment before it can be used for neutron diffraction experiments.

556) Answer the following question.
(a) Quarks inside protons and neutrons are thought to carry fractional charges $\left(+\frac{2}{3}e, -\frac{1}{3}e\right)$. Why do they not show up in Millikan's oil drop experiment?
(b) What is so special about the combination elm? Why do we not simply talk of e and m specially?
(c) Why should gases be insulators at ordinary pressure and start conducting at very low pressure.
(d) Every metal has a definite work function, Why do photoelectrons not come out all with same energy if incident radiations is monochromatic?Why is there an energy distribution of photoelectrons?
(e) The energy and momentum of an electron are related to the frequency and wavelength of the associated matter wave by the relations : $E = hv, p = \frac{h}{\lambda}$
But while the value of λ is physically significant, the value of v (and therefore the value of the phase speed $v\lambda$) has no physical significance. Why?

557) Consider a thin target $(10^{-2}$ m square, 10^{-3} m thickness) of sodium, which produces a photocurrent of $100\mu A$ when a light of intensity 100w/m^2 ($(\lambda = 660nm)$ falls on it. Find the probability that a photoelectron is produced when a photon strikes a sodium atom.[Take density of Na = 0.97 kg/m^3

558) Consider an electron in front of metallic surface at a distance d (treated as an infinite plane surface). Assume the force of attraction by the plate is given as $\frac{1}{4}\frac{q^2}{4\pi e_0 d^2}$
Calculate work in taking the charge to an infinite distance from the plate. Taking d = 0.1 nm, find the work done in electron volts. [Such a force law is not valid for d < 0.1 nm].

559) An electron and photon each have a wavelength 1.00nm Find
(i) their moment
(ii) the energy of the photon and
(iii) the kinetic energy of electron.

560) The following table gives the values of work function for a few photosensitive metals:

S.No	Metal	Work function
1	Na	1.92
2	K	2.15
3	MO	4.17

If each of these metals is exposed to radiations of wavelength 300nm, which of them will not emit photoelectrons and why?
$\left[Use\ h = 6.6 \times 10^{-34} Js; c = 3 \times 10^8 ms^{-1}\right]$

561) By how much would the stopping potential for a given photosensitive surface go up if the frequency of the incident radiations were to be increased from $4 \times 10^5 Hz$ to $8 \times 10^{15} Hz$? Given,
$h = 6.6 \times 10^{-34} Js, e = 1.6 \times 10^{-19} C\ and\ c = 3 \times 10^8 ms^{-1}$

562) Work function of sodium is 2.3eV. Does sodium photoelectric emission for orange light $(\lambda = 6800\overset{\circ}{A})$? Given $h = 6.63 \times 10^{-34} Js$

563) A metal has a work function of 2.0 eV and is illuminated by monochromic light of wavelength 500nm. Calculate
(a) the threshold wavelength
(b) the maximum energy of photoelectrons
(c) the stopping potential.
$[use\ h = 6.63 \times 10^{-34} Js; c = 3 \times 10^8 ms^{-1}]$

564) Photoelectrons are emitted from a metal surface when ultraviolet light of wavelength 300nm is incident on it. The minimum negative potential required to stop the emission of electrons is 0.54V. Calculate:
(i) the energy of the incident photons
(ii) the maximum kinetic energy of the photoelectrons emitted
(iii) the work function of the metal
Express all answers in eV.
$Use\ h = 6.63 \times 10^{-34} Js$

565) By how much would the stopping potential for a given photosensitive surface go up if the frequency of the incident radiations were to be increased from $6 \times 10^{15} Hz\ to\ 16 \times 10^{15} Hz$?Given
$h = 6.4 \times 10^{-34} Js, e = 1.6 \times 10^{-19} C\ and\ c = 3 \times 10^8 m/s$

566) Light of wavelength $5000\overset{\circ}{A}$ falls on a metal surface of work function 1.9eV. Find
(i) the energy of photons in eV
(ii) the kinetic energy of photoelectrons and
(iii) the stopping potential.Use $h = 6.63 \times 10^{-34} Js, c = 3 \times 10^8 ms^{-1}; e = 1.6 \times 10^{19} C$

567) (a) The work function for the surface of aluminum is 4.2 eV. How much potential difference will be required to stop the emission of maximum energy electrons emitted by light of $2000\overset{\circ}{A}$ wavelength?
(b) What will be the wavelength of that incident light for which stopping potential will be zero?
$h = 6.63 \times 10^{-34} Js, c = 3 \times 10^8 ms^{-1}$

568) When a piece of metal is illuminated by monochromic light of wavelength λ then the stopping potential for photoelectric current is 2.5.V_0 When the same surface is illuminated by light of wavelength 1.5λ then the stopping potential becomes.V_0 Find the value of threshold wavelength for photoelectric emission.

569) A monochromatic source, emitting light of wavelength, 600 nm, has a power output of 66W. Calculate the number of photons emitted by this source in 2 minutes. Use, h = 6.63 x 10^{-34}J

570) How many photons are received on earth's per cm^2 per hour if the energy from the sun reaching on the earth is at the rate of 2 cal cm^{-2} min^{-1} and average wavelength of solar light be taken as $5500\overset{\circ}{A}$.
Use $h = 6.63 \times 10^{-34} J, c = 3 \times 10^8 ms^{-1} and\ 1\ cal = 4.2J$

571) If 10% of the energy supplied to an incandescent light bulb is radiated as visible light, how many visible light photons are emitted by 200-watt bulb? Assume wavelength of all visible photons to be $5000\overset{\circ}{A}$ Given
$h = 6.63 \times 10^{-34} Js$

572) The wavelength of light in the visible region about 390nm for violet colour, about 550nm (average wavelength) for yellow-green colour and about 760nm for red colour.
(a) What are the energies of photon in eV at the (i) violet and (ii) average wavelength yellow-green colour and (iii) red end of the visible spectrum? (Take $h = 6.63 \times 10^{-34} Js$ and 1 eV = $1.6 \times 10^{-19} J$)
(b) From which of the photosensitive materials with work functions listed in Table 11.1 and using the results of (i), (ii) and (iii) of (a), can you build a photoelectric device that operates with visible light?

573) The kinetic energy of the electron orbiting in the first excited state of hydrogen atom is 3.4 eV. Determine the de-Broglie wavelength associated with it.
Mass of electron = $9.1 \times 10^{-31} Kg$;
Planck's constant = $6.63 \times 10^{-34} Js$

574) The wavelength λ of a photon and the de-Broglie wavelength o an electron have the same value. Show that the energy of the photon is $\frac{2\lambda mc}{h}$ times the kinetic energy of the electron, where m, c and h have their usual meanings.

575) Find the de-Broglie wavelength(in $\overset{\circ}{A}$) associated with an example with an electron moving with a velocity 0.6c, where c=$3 \times 10^{8} m/s$ and rest mass of electron=$9.1 \times 10^{-31} kg$, $h = 6.6 \times 10^{-34} Js$

576) Find DE-Broglie wavelength of neutron at$127^{\circ} C$. Given Boltzmann constant,
$K = 1.38 \times 10^{-23} Jmole^{-1} K^{-1}, h = 6.63 \times 10^{-34} Js,$ mass of neutron =
$1.66 \times 10^{-27} kg$

577) For what kinetic energy of a proton, will the associated de-Broglie wavelength be 16.5 nm? Mass of proton =
$1.675 \times 10^{-27} kg, h = 6.63 \times 10^{-34} Js$

578) X-rays of wavelength $0.82\overset{\circ}{A}$ fall on a metal plate. Find the wavelength associated with photoelectron emitted. Neglect work function of the metal. Given $h = 6.6 \times 10^{-34} Js; c = 3 \times 10^{8} ms^{-1}$

579) A stopping potential of 0.82 volt is required to stop the emission of photoelectrons from the surface of a metal by light of wavelength.$4000\overset{\circ}{A}$ For light of wavelength, $3000\overset{\circ}{A}$ the stopping potential is 1.85 volt.Find the value of Plank's constant
$\left[1eV = 1.6 \times 10^{-19} J\right]$

(ii) At stopping potential if the wavelength of light is kept fixed at $4000\overset{\circ}{A}$, but the intensity of light increased two times, will photoelectric current be obtained? Give reason for your answer.

580) Light of wavelength $4000\overset{\circ}{A}$ is incident on barium. Photoelectrons emitted describe a circle of radius 50 cm by a magnetic field of flux density $5.26 \times 10^{-6} tesla$. What is the work function of barium in eV? Given
$h = 6.6 \times 10^{-34} Js; e = 1.6 \times 10^{-19} C; m_e = 9.1 \times 10^{-31} kg$

581) The extent of localisation of a particle is determined by its de-Broglie wavelength.If an electron is localised within the nucleus(of size about 10^{-14})of an atom, what is it energy? Compare this energy with the typical binding energies(of the order of a few MeV) in a nucleus and hence argue why electron cannot reside in a nucleus.

582) A 100W sodium lamp radiates energy uniformly in all directions.The lamp is located at the centre of a large sphere that absorbs all the sodium light which is incident on it.The wavelength of the sodium light is 589nm.
(a) What is energy associated per photon with the sodium light?
(b) At what rate are the photons delivered to the sphere?

583) Calculate the (a) momentum and (b) de-Broglie wavelength of the electrons accelerated through a potential difference of 56 V.

584) What is the
(a) momentum
(b) speed and
(c) de-Broglie wavelength of an electron with kinetic energy of 120 eV.

585) The wavelength of light from the spectral emission line of sodium is 589nm. Find the kinetic energy at which (a) an electron (b) a neutron, would have the same de-Broglie wavelength.
$h = 6.63 \times 10^{-34} Js; 1eV = 1.6 \times 10^{-19} J; m_e = 9.1 \times 10^{-31} kg;$

586) What is the de-Broglie wavelength of a nitrogen molecule in air at 300K? Assume that the molecule is moving with the root-mean-square speed of molecules at this temperature.(Atomic mass of nitrogen = 14.0076 u)

587) (a) Estimate the speed with which electrons emitted from a heated cathode of an evacuated tube impinge on the anode maintained at a potential difference of 500V with respect to the cathode. Ignore the small initial speeds of the electrons. The specific charge of the electron, i.e., its e/m is given to be $1.76 \times 10^{11} Ckg^{-1}$
(b) Use the same formula you employ in (a) to obtain electron speed for an anode potential of 10MV. Do you see what is wrong? In what way is the formula to be modified?

588) The wavelength of a probe is roughly a measure of the size of a structure that it can probe in some detail.The quark structure of protons and neutrons appears at the minute length-scale of 10^{-15} m or less.This structure was first probed in early 1970's using high energy electron beam produced by a linear accelerator at Stanford, USA.Guess what might have been the order of energy of these electron beams (Rest mass energy of electron=0.511MeV)

589) Find the typical de-Broglie wavelength associated with a He atom in helium gas at room temperature$(27^{\circ}C)$ and 1 atm pressure; and compare it with the mean separation between two atoms under these conditions.

590) Compute the typical de-Broglie wavelength of an electron in a metal at $(27^{\circ}C)$ and compare it with the mean separation between two electrons in a metal which is given to be about $2\times10^{-10}m$

591) Work function of a metal is the minimum amount of energy required by an electron to just escape from the metal surface without any kinetic energy. The expression for work function of metal is
$\phi_0 = hv_0 = hc/\lambda_0$
where h is Plank's constant;v_0 is the threshold wavelength and c is the velocity of light in vacuum.
(i) Why different metals has different work function?
(ii) What is the threshold wavelength of the incident radiation for a metal surface whose work function is 1.2 eV.
Given $h=6.63\times10^{-34}Js; \qquad 1eV=1.6\times10^{-19}J$
(iii) What do you learn from this study?

592) Radiation has dual nature,i.e., it possesses the properties of both; wave and particle.This prompted de-Broglie to predict dual nature of moving material particles.Thus waves are associated with moving material particles which are called matter waves. The wavelength of matter wave is given by $\lambda=\frac{h}{mv}$, where m is the mass, v is the speed of the particle and h is Plank's constant. Read the above paragraph and answer the following questions;
(i) How was the wave nature of the electron established?
(ii) What are the de-Broglie wavelength associated with a particle (i) at rest (ii) moving with infinite speed?
(iii) What are the basic values displayed with this study?

593) According to Plank's constant quantum theory of light, every source of radiation emits photons(i.e., packets of energy) which travel in all directions with the same speed (i.e., speed of light). Each photon is of energy
$E=hv=\frac{hc}{\lambda}$ where h is plank's constant, v is the frequency and λ is wavelength of radiation emitted. The photons emitted from different sources of radiation are different.
Read the above passage and answer the following questions:
(i) On what factors does the number of photons emitted per second from a source of radiation depend?
(ii) Why are the high energy photons not visible to eye?
(iii) Which basic values do you learn from this study?

594) "Know your face beauty through comp[lexion meter" was one of the stall on science exhibition. A student interested to know his/her face beauty was made to stand on a platform and light from a lamp was made to fall on his/her face. The reading of complexion meter indicated the face beauty of the student which might be very fair, fair,semi-fair, semidark dark etc.
(i) What is the basic concept used in the working of complexion meter?
(ii) How is the face beauty recorded by face complexation meter?
(iii) What basic values do you learn from the above study?

595) The photoelectric effect is a phenomenon of emission of electrons from the surface of a metal when the light of suitable frequency falls on it.
If light of frequency v falls on a photosensitive surface of work function increases or work function then the maximum kinetic energy of photoelectric emitted is given by Einstein's photoelectric equation.
$(KE)_{max}=\frac{1}{2}mv^2{}_{max}=hv-\phi_0$
The value $(KE)_{max}$ will increase if the energy of the incident light(hv) increases or work function ϕ_0 is decreased.
Read above passage and answer the following questions:
(i) Why can visible light not eject photoelectrons from every metal surface?
(ii) Light of frequency $7.21\times10^{14}Hz$ is incident on a metal surface.Electrons with a maximum speed of $6.0\times10^5ms^{-1}$ are ejected from the surface. What is the threshold frequency for photo emission of electrons?$h=6.63\times10^{-34}Js;\ m_e=9.1\times10^{-31}kg$
(iii) What do you learn basically from the above study?

596) Neha's brother was riding the bike on the highway and she was sitting behind him. While sitting, at a place traffic signal turned red from green and her brother continued riding without noticing the signal change. Neha observed the whole situation and asked her brother to stop. Her brother felt happy on his sister's intelligence.

Read above passage and answer the following questions:

(i) Why Neha's brother became happy? What kind of value is expressed by Neha?

(ii) What are the principles that are used in maintaining traffic signals?

(iii) What is the leading physical quantity i8n the process? Write an equation for the speed of the photoelectron.

597) (i) A monoenergetic electron beam with electron speed of $5.20 \times 10^6 m/s$ is subject to a magnetic field of $1.30 \times 10^{-4} m/s$ T normal to the beam velocity. What is the radius of the circle traced by the beam, given e/m for electron equals $1.76 \times 10^{11} c/kg$?

(ii) Is the formula you employ in (i) valid for calculating the radius of the path of a 20 MeV electron beam? if not, in what way is it modified?