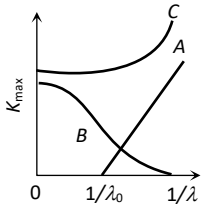
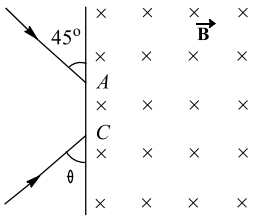
DUAL NATURE OF MATTER AND RADIATION

Single Correct Answer Type

1. If the linear momentum of a particle is 2.2×10^4 kg-ms^{-1}, then what will be its de-Broglie wavelength? (Take $h = 6.6 \times 10^{-34}$ Js)
   a) 3×10^{-29}m b) 3×10^{-29}nm
   c) 6×10^{-29}m d) 6×10^{-29}nm
2. The correct graph between the maximum energy of a photoelectron and the inverse of wavelength of the incident radiation is given by the curve



   a) A b) B
   c) C d) None of the above
3. Which phenomenon best supports the theory that matter has a wave nature
   a) Electron momentum b) Electron diffraction
   c) Photon momentum d) Photon diffraction
4. Planck's constant has the dimensions of
   a) Energy b) Mass
   c) Frequency d) Angular momentum
5. A proton of mass 1.67×10^{-27} kg enters a uniform magnetic field of 1 T at point A as shown in figure, with a speed of 10^7 ms^{-1}. The magnetic field is directed normal to the plane of paper downwards. The proton emerges out of the magnetic field at point C, then the distance AC and the value of angle θ will respectively be



   a) 0.7 m, 45° b) 0.7 m, 90°
   c) 0.14 m, 90° d) 0.14 m, 45°
6. What will be the number of photons emitted per second by a 10 W sodium vapour lamp assuming that 90% of the consumed energy is converted into light? Wavelength of sodium light is 590 nm, $h = 6.63 \times 10^{-34}$J-s.
   a) 0.267×10^{18} b) 0.267×10^{19}
   c) 0.267×10^{20} d) 0.267×10^{17}
7. The work function for metals A, B and C are respectively 1.92 eV, 2.0 eV and 5 eV. According to Einstein's equation, the metals which will emit photo electrons for a radiation of wavelength 4100 Å is/are
   a) None of these b) A only
   c) A and B only d) All the three metals

8. If the voltage of X-rays tube is doubled, the intensity of X-rays will become
   a) Half b) Unchanged
   c) Double d) Four times
9. A photon of energy 8 eV is incident on a metal surface of threshold frequency $1.6 \times 10^{15} Hz$, then the maximum kinetic energy of photoelectrons emitted is ($h = 6.6 \times 10^{-34} Js$)
   a) 4.8 eV b) 2.4 eV
   c) 1.4 eV d) 0.8 eV
10. Ultraviolet radiations of 6.2 eV falls on an aluminium surface. KE of fastest electron emitted is (work function = 4.2 eV)
   a) $3.2 \times 10^{-21} J$ b) $3.2 \times 10^{-19} J$
   c) $7 \times 10^{-25}\ J$ d) $9 \times 10^{-32}\ J$
11. In X-ray tube when the accelerating voltage V is halved, the difference between the wavelength of K_α line and minimum wavelength of continuous X-ray spectrum
   a) Remains constant b) Becomes more than two times
   c) Becomes half d) Becomes less than two times
12. Which of the following metal thermionically emits an electron at a relatively lowest temperature among them
   a) Platinum b) Copper
   c) Aluminium d) Molybdenum
13. J. J. Thomson's cathode ray tube experiment demonstrated that
   a) Cathode rays are streams of negatively charged ions
   b) All the mass of an atom is essentially in the nucleus
   c) The e/m of electrons is much greater than the e/m of protons
   d) The e/m ratio of the cathode ray particles changes when a different gas is placed in the discharge tube
14. Which one of the following statement is wronge in the context of X-rays generated from X-ray tube?
   a) Wavelength of characteristic X-rays decreases when the atomic number of the target increases
   b) Cut-off wavelength of the continuous X-rays depends on the atomic number of the target
   c) Intensity of the characteristic X-rays depends on the electrical power given to the X-ray tube
   d) Cut-off wavelength of the continuous X-rays depends on the energy of the electrons in X-ray tube
15. The de-Broglie wavelength associated with the particle of mass m moving with velocity v is
   a) h/mv b) mv/h
   c) mh/v d) m/hv
16. Which is not true with respect to the cathode rays
   a) A stream of electrons
   b) Charged particles
   c) Move with speed same as that of light
   d) Can be deflected by magnetic fields
17. The specific charge of a proton is $9.6 \times 10^7\ Ckg^{-1}$.The specific charge of an alpha particle will be
   a) $9.6 \times 10^7\ Ckg^{-1}$ b) $19.2 \times 10^7\ Ckg^{-1}$
   c) $4.8 \times 10^7\ Ckg^{-1}$ d) $2.4 \times 10^7\ Ckg^{-1}$
18. If an electron and proton are propagating in the form of waves having the same wavelength, it implies that they have the same
   a) Energy b) Momentum
   c) Velocity d) Angular momentum

19. When an inert gas is filled in place of vacuum in a photo cell, then
    a) Photo-electric current is decreased
    b) Photo-electric current is increased
    c) Photo-electric current remains the same
    d) Decrease or increase in photo-electric current does not depend upon the gas filled
20. The X-ray beam coming from an X-ray tube will be
    a) Monochromatic
    b) Having all wavelengths smaller than a certain maximum wavelength
    c) Having all wavelengths larger than a certain minimum wavelength
    d) Having all wavelengths lying between a minimum and a maximum wavelength
21. If an electron and a photon propagate in the form of waves having the same wavelength, it implies that they have the same
    a) Energy b) Momentum
    c) Velocity d) Angular momentum
22. An X-ray tube is operated at 50 kV. The minimum wavelength produced is
    a) 0.5 Å b) 0.75 Å
    c) 0.25 Å d) 1 Å
23. The energy that should be added to an electron to reduce its de-Broglie wavelength from 1 nm to 0.5 nm is
    a) Four times the initial energy b) Equal to the initial energy
    c) Twice the initial energy d) Thrice the initial energy
24. By photoelectric effect, Einstein, proved
    a) $E = hv$ b) $K.E. = \frac{1}{2}mv^2$
    c) $E = mc^2$ d) $E = \frac{Rhc^2}{n^2}$
25. If a cathode ray tube has a potential difference V volt between the cathode and anode, then the speed v of cathode rays is given by
    a) $v \propto V^2$ b) $v \propto \sqrt{V}$
    c) $v \propto V^{-1}$ d) $v \propto V$
26. The light rays having photons of energy 1.8 eV are falling on a metal surface having a work function 1.2 eV. What is the stopping potential to be applied to stop the emitting electrons
    a) 3 eV b) 1.2 eV
    c) 0.6 eV d) 1.4 eV
27. The energy of a photon of light with wavelength 5000 Å is approximately 2.5 eV. This way the energy of an X-ray photon with wavelength 1Å would be
    a) $2.5/5000\ eV$ b) $2.5/(5000)^2 eV$
    c) $2.5 \times 5000\ eV$ d) $2.5 \times (5000)^2 eV$
28. Light of wavelength 4000 Å incident on a sodium surface for which the threshold wavelength of photoelectrons is 5420 Å. The work function of sodium is
    a) 0.57 eV b) 1.14 eV
    c) 2.29 eV d) 4.58 eV
29. The mass of a photo electron is
    a) $9.1 \times 10^{-27} kg$ b) $9.1 \times 10^{-29} kg$
    c) $9.1 \times 10^{-31} kg$ d) $9.1 \times 10^{-34} kg$

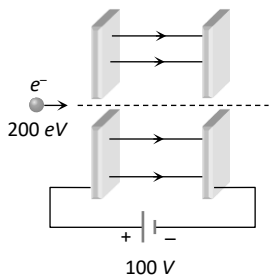
30. During X-ray production from coolidge tube if the current in increased, then
    a) The penetration power increases
    b) The penetration power decreases
    c) The intensity of X-rays increases
    d) The intensity of X-rays decreases

31. Cathode rays are
    a) Positive rays
    b) Neutral rays
    c) He rays
    d) Electron waves

32. K_α and K_β X-rays are emitted when there is a transition of electron between the levels
    a) n=2 to n=1 and n=3 to n=1 respectively
    b) n=2 to n=1 and n=3 to n=2 respectively
    c) n=3 to n=2 and n=4 to n=2 respectively
    d) n=3 to n=2 and n=4 to n=3 respectively

33. A beam of light of wavelength λ and with illumination L falls on a clean surface of sodium. If N photoelectrons are emitted each with kinetic energy E, then
    a) $N \propto L$ and $E \propto L$
    b) $N \propto L$ and $E \propto \frac{1}{\lambda}$
    c) $N \propto \lambda$ and $E \propto L$
    d) $N \propto \frac{1}{\lambda}$ and $E \propto \frac{1}{L}$

34. Two large parallel plates are connected with the terminal of 100 v power supply. These plates have a fine hole at the centre. An electron having energy 200 eV is so directed that it passes through the holes. When if comes out it's de-Broglie wavelength is



    a) 1.22 Å
    b) 1.75 Å
    c) 2 Å
    d) None of these

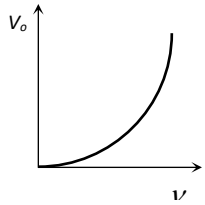
35. An electromagnetic radiation has an energy of 13.2 keV. Then the radiation belongs to the region of
    a) Visible light
    b) Ultraviolet
    c) Infrared
    d) X-ray

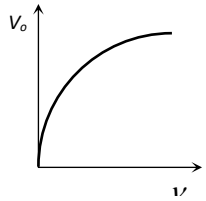
36. The energy of a photon is equal to the kinetic energy of a photon. The energy of a the photon is E. Let λ_1 be the de-Broglie wavelength of the photon and λ_2 be the wavelength of the photon. The ratio $\frac{\lambda_1}{\lambda_2}$ proportional to
    a) E^0
    b) $E^{1/2}$
    c) E^{-1}
    d)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

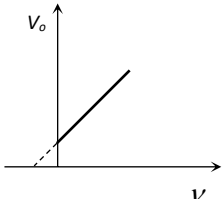
37. In a photoemissive cell with exciting wavelength λ, the fastest electron has speed v. If the exciting wavelength is changed to $3\lambda/4$, the speed of the fastest emitted electron will be
    a) $v(3/4)^{1/2}$
    b) $v(4/3)^{1/2}$
    c) Less than $v(4/3)^{1/2}$
    d) Greater than $v(4/3)^{1/2}$

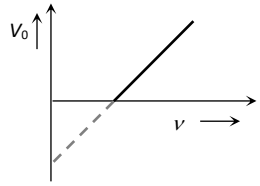
38. The minimum wavelength of X-rays produced in a coolidge tube operated at potential difference of 40 kV is
    a) 0.31 Å
    b) 3.1 Å
    c) 31 Å
    d) 311 Å

39. For a photoelectric cell the graph showing the variation of cut off voltage (V_o) with frequency (v) of incident light is best represented by

a) 

b) 

c) 

d) 

40. A charge of magnitude3e and mass 2m is moving in an electric field **E**. The acceleration imparted to the charge is

a) $2\ Ee/3m$ b) $3\ Ee/2m$
c) $2\ m/3Ee$ d) $3\ m/2Ee$

41. X-rays are produced in laboratory by

a) Radiation
b) Decomposition of the atom
c) Bombardment of high energy electron on heavy metal
d) None of these

42. A beam of cathode rays is subjected to crossed Electric (E) and Magnetic field (B). The fields are adjusted such that the beam is not deflected. The specific charge of the cathode rays is given by

a) $\frac{E^2}{2VB^2}$ b) $\frac{B^2}{2VE^2}$
c) $\frac{2VB^2}{E^2}$ d) $\frac{2VE^2}{B^2}$

43. Cathode rays enter a magnetic field making oblique angle with the lines of magnetic induction. What will be the nature of the path followed?

a) Parabola b) Helix
c) Circle d) Straight line

44. Monochromatic radiation emitted when electron on hydrogen atom jumps from first excited to the ground state irradiates a photosensitive material. The stopping potential is measured to be 3.57 V. the threshold frequency of the material is

a) $4 \times 10^{15} Hz$ b) $5 \times 10^{15} Hz$
c) $1.6 \times 10^{15} Hz$ d) $2.5 \times 10^{15} Hz$

45. The wavelength λ of the K_α line of characteristic X-rays spectra varies with atomic number approximately

a) $\lambda \propto Z$ b) $\lambda \propto \sqrt{Z}$
c) $\lambda \propto \frac{1}{Z^2}$ d) $\lambda \propto \frac{1}{\sqrt{Z}}$

46. In Millikans oil drop experiment, a charged drop of mass $1.8 \times 10^{-14} kg$ is stationary between its plates. The distance between its plates is 0.90 cm and potential difference is 2.0 $kilo\ volts$. The number of electrons on the drop is

a) 500 b) 50
c) 5 d) 0

47. If n_R and n_V denote the number of photons emitted by a red bulb and violet bulb of equal power in a given time, then

a) $n_R = n_V$ b) $n_R > n_V$

c) $n_R < n_V$ d) $n_R \geq n_V$

48. X-rays are

a) Stream of electrons

b) Stream of positively charged particles

c) Electromagnetic radiantions of high frequency

d) Stream of uncharged particles

49. What is the de-Broglie wavelength of the α-particle accelerated through a potential difference V

a) $\frac{0.287}{\sqrt{V}}$ Å b) $\frac{12.27}{\sqrt{V}}$ Å

c) $\frac{0.101}{\sqrt{V}}$ Å d) $\frac{0.202}{\sqrt{V}}$ Å

50. An electron with (rest mass m_0) moves with a speed of $0.8c$. Its mass when it moves with this speed is

a) m_0 b) $m_0/6$

c) $5m_0/3$ d) $3m_0/5$

51. Sodium and copper have work functions $2.3\,eV$ and $4.5\,eV$ respectively. Then the ratio of their threshold wavelengths is nearest to

a) 1 :2 b) 4 :1

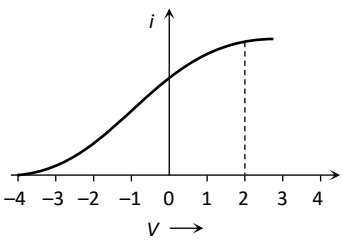
c) 2 :1 d) 1 :4

52. An α-particle of mass 6.4×10^{-27}kg and charge 3.2×10^{-19} C is situated in a uniform electric field of $1.6 \times 10^5\ Vm^{-1}$. The velocity of the particle at the end of 2×10^{-2} m path when it starts from rest is

a) $2\sqrt{3} \times 10^5 ms^{-1}$ b) $8 \times 10^5\ ms^{-1}$

c) $16 \times 10^5\ ms^{-1}$ d) $4\sqrt{2} \times 10^5\ ms^{-1}$

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



a) $2eV$ b) $4\ eV$

c) $0\ eV$ d) $4\ J$

54. If energy of K-shell electron is $-40000\ eV$ and If $60000\ V$ potential is applied at coolidge tube then which of the following X-ray will from?

a) Continuous

b) White X-rays

c) Continuous and all series of characteristic

d) None of these

55. An electron and a proton are moving in the same direction with same kinetic energy. The ratio of the de- Broglie wavelength associated with these particles is

a) $\frac{m_e}{m_p}$ b) $\frac{m_p}{m_e}$

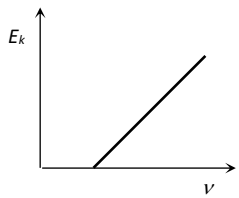
c) $\sqrt{\frac{M_p}{M_e}}$ d) $m_p . m_e$

56. When X rays pass through a strong uniform magnetic field. Then they
   a) Do not get deflected at all
   b) Get deflected in the direction of the field
   c) Get deflected in the direction opposite to the field
   d) Get deflected in the direction perpendicular to the field

57. A proton and an α-particle are accelerated through a potential difference of 100 V. The ratio of the wavelength associated with the proton to that associated with an α-particle is
   a) $\sqrt{2} : 1$ b) $2 : 1$
   c) $2\sqrt{2} : 1$ d) $\frac{1}{2\sqrt{2}} : 1$

58. In a discharge tube ionization of enclosed gas is produced due to collisions between
   a) Photons and neutral atoms/molecules
   b) Neutral gas atoms/molecules
   c) Positive ions and neutral atoms/molecules
   d) Negative electrons and neutral atoms/molecules

59. For the photoelectric effect, the maximum kinetic energy E_k of the emitted photoelectrons is plotted against the frequency v of the incident photons as shown in the figure. The slope of the curve gives



   a) Charge of the electron
   b) Work function of the metal
   c) Plank's constant
   d) Ratio of the Plank's constant to electronic charge

60. The wavelength of the photoelectric threshold for silver is λ_0. The energy of the electron ejected from the surface of silver by an incident light of wavelength $\lambda(\lambda < \lambda_0)$ will be
   a) $hc(\lambda_0 - \lambda)$ b) $\frac{hc}{\lambda_0 - \lambda}$
   c) $\frac{h}{c}\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)$ d) $hc\left(\frac{\lambda_0 - \lambda}{\lambda_0 \lambda}\right)$

61. If an electron and a proton have the same de-Broglie wavelength, then the kinetic energy of the electron is
   a) Zero b) Less than that of a proton
   c) More than that of a proton d) Equal to that of a proton

62. A particle of mass M at rest decays into two masses m_1 and m_2 with non-zero velocities. The ratio of de-Broglie wavelengths of the particles $\frac{\lambda_1}{\lambda_2}$ is
   a) $\frac{m_2}{m_1}$ b) $\frac{m_1}{m_2}$
   c) $\frac{\sqrt{m_1}}{\sqrt{m_2}}$ d) 1:1

63. The de-Broglie wavelength of the electron in the ground state of the hydrogen atom is (Radius of the first orbit of hydrogen atom =0.53Å)
   a) 1.67 Å b) 3.33 Å
   c) 1.06 Å d) 0.53 Å

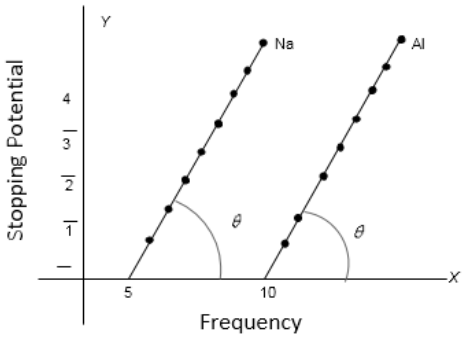
64. Energy of characteristic X-ray is a consequence of
   a) Energy of projectile electron b) Thermal energy of target
   c) Transition in target atoms d) None of the above

65. X-ray beam of intensity I_0 passes through an absorption plate of thickness d. If absorption coefficient of material of plate is μ, the correct statement regarding the transmitted intensity I of X-ray is

a) $I = I_0(1 - e^{-\mu d})$ b) $I = I_0 e^{-\mu d}$

c) $I = I_0(1 - e^{-\mu/d})$ d) $I = I_0 e^{-\mu/d}$

66. From the figure describing photoelectric effect we may infer correctly that



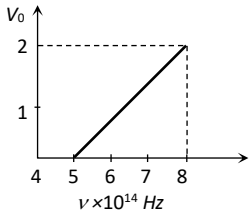
a) Na and Al both have the same threshold frequency

b) Maximum kinetic energy for both the metals depend linearly on the frequency

c) The stopping potentials are different for Na and Al for the same change in frequency

d) Al is a better photo sensitive material than Na

67. The stopping potential (V_0) versus frequency (v) plot of a substance is shown in figure the threshold wave length is



a) $5 \times 10^{14} m$ b) 6000 Å

c) 5000 Å d) Cannot be estimated from given data

68. A photon and an electron have an equal energy$E$.

a) $\sqrt{E}$ b) $1/\sqrt{E}$

c) $1/E$ d) Does not depend upon E

69. If the work function of a photometal is 6.825 eV. Its threshold wavelength will be ($c = 3 \times 10^8\ m/s$)

a) 1200 Å b) 1800 Å

c) 2400 Å d) 3600 Å

70. X-rays of wavelength 0.140 nm are scattered from a block of carbon. What will be the wavelenghts of X-rays scattered at 90^0?

a) 0.140 nm b) 0.142 nm

c) 0.144 nm d) 0.146 nm

71. The wavelength of most energetic X-rays emitted when a metal target is bombarded by $40KeV$ electrons, is approximately

($h = 6.62 \times 10^{-34} J\text{-}sec, 1\ eV = 1.6 \times 10^{-19} J; c = 3 \times 10^8 m/s$)

a) 300 Å b) 10 Å

c) 4 Å d) 0.31 Å

72. If the mass of neutral $= 1.7 \times 10^{-27}$kg, then the de-Broglie wavelength of neutral of energy 3eV is ($h = 6.6 \times 10^{-34} J - s$)

a) 1.6×10^{-16}m b) 1.6×10^{-11}m

c) 1.4×10^{-10}m d) 1.4×10^{-11}m

73. X-rays when incident on a metal
a) Exert a force on it b) Transfer energy to it
c) Transfer pressure to it d) All of the above

74. Penetrating power of X-rays depends on
a) Current flowing in the filament b) Applied potential difference
c) Nature of the target d) All the above

75. If source of power 4 kW produces 10^{20} photon/ second, the radiation belong to a part of the spectrum called
a) X-rays b) Ultraviolet rays
c) Microwaves d) γ-rays

76. On increasing the number of electrons striking the anode of an X-ray tube, which one of the following parameters of the resulting X-rays would increase?
a) Penetration b) Frequency
c) Wavelength d) Intensity

77. According to photon theory of light which of the following physical quantities associated with a photon do not/does not change as it collides with an electron in vacuum
a) Energy and momentum b) Speed and momentum
c) Speed only d) Energy only

78. Radiations of two photon's energy, twice and ten times the work function of metal are incident on the metal surface successively. The ratio of maximum velocities of photoelectrons emitted in two cases is
a) 1 : 2 b) 1 : 3
c) 1 : 4 d) 1 : 1

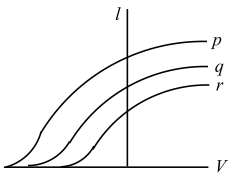
79. What should be the velocity of an electron so that its momentum becomes equal to that of a photon of wavelength 5200 Å?
a) 700 ms^{-1} b) 1000 ms^{-1}
c) 1400 ms^{-1} d) 2800 ms^{-1}

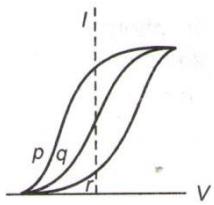
80. Intensity of X-rays depends upon the number of
a) Electrons b) Protons
c) Neutrons d) Positrons

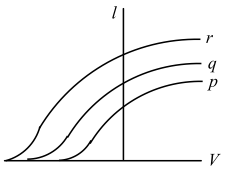
81. An α-particle and a proton are accelerated from rest by a potential difference of 100 V. After this, their de-Broglie wavelengths are λ_α and λ_p respectively. The ratio $\frac{\lambda_p}{\lambda_\alpha}$, to the nearest integer, is
a) 3 b) 4
c) 2 d) 4.5

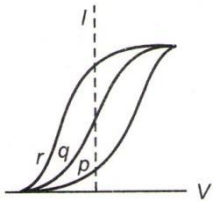
82. When a proton is accelerated with 1 $volt$ potential difference, then its kinetic energy is
a) $\frac{1}{1840} eV$ b) 1840 eV
c) 1 eV d) 1840 c^2 eV

83. Photoelectric effect experiments are performed using three different metal plates p,q and r having work functions $\phi_p = 2.0\ eV, \phi_q = 2.5\ eV$ and $\phi_r 3.0\ eV$, respectively
A light beam containing wavelengths of 550 nm, 450 nm and 350 nm with equal intensities illuminates each of the plates. The correct I-V graph for the experiment is

a) 

b) 

c) 

d) 

84. Energy conversion in a photoelectric cell takes place form
a) Chemical to electrical b) Magnetic to electrical
c) Optical to electrical d) Mechanical to electrical

85. Which of the following devices makes use of the electrons to strike certain substances to produce fluorescence
a) Thermionic valve b) Photoelectric cell
c) Cathode ray oscilloscope d) Electron gun

86. Photoelectric effect was first successfully explained by
a) Planck b) Hallwach
c) Hertz d) Einstein

87. If particles are moving with same velocity, then maximum de-Bronglie wavelength will be for
a) Neutron b) Proton
c) β-particle d) α-particle

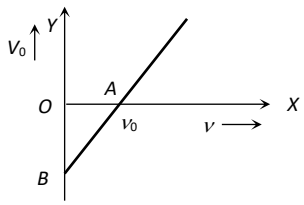
88. Photoelectric effect supports quantum nature of light because
I. There is minimum frequency of light below which no photoelectrons are emitted.
II. Electric charge of photoelectrons is quantized.
III. Maximum kinetic energy of photoelectrons depends only on the frequency of light and not on its intensity.
IV. Even when metal surface is faintly illuminated the photoelectrons leave the surface immediately.
a) 1,2,3 b) 1,2,4
c) 2,3,4 d) 1,3,4

89. For the production of X-rays, the target should be made of
a) Steel b) Copper
c) Aluminimum d) Tungsten

90. The frequency of the incident light falling on a photosensitive metal plate is doubled, the kinetic energy of the emitted photoelectron is
a) Double the earlier value b) Unchanged
c) More than doubled d) Less than doubled

91. The specific charge of a proton is $9.6 \times 10^7\ C\ Kg^{-1}$. The specific charge of an alpha particle will be
a) $9.6 \times 10^7\ C\ Kg^{-1}$ b) $19.2 \times 10^7\ C\ Kg^{-1}$
c) $4.8 \times 10^7\ C\ Kg^{-1}$ d) $2.4 \times 10^7\ C\ Kg^{-1}$

92. In an experiment on photoelectric effect the frequency f of the incident light is plotted against the stopping potential V_0. The work function of the photoelectric surface is given by (e is electronic charge)



a) $OB \times e\ in\ eV$ b) OB in $volt$
c) OA in eV d) The slope of the line AB

93. A $1\mu A$ beam of protons with a cross-sectional area of $0.5\, sq.mm$ is moving with a velocity of $3 \times 10^4 ms^{-1}$. Then charge density of beam is
a) $6.6 \times 10^{-4} C/m^3$ b) $6.6 \times 10^{-5} C/m^3$
c) $6.6 \times 10^{-6} C/m^3$ d) None of these

94. A photon of energy E ejects a photoelectrons from a metal surface whose work function is W_0. If this electron enters into a uniform magnetic field of induction B in a direction perpendicular to the field and describes a circular path of radius r, then the radius r, is given by, (in the usual notation)
a) $\sqrt{\frac{2m(E-W_0)}{eB}}$ b) $\sqrt{2m(E-W_0)eB}$
c) $\frac{\sqrt{2e(E-W_0)}}{mB}$ d) $\frac{\sqrt{2m(E-W_0)}}{eB}$

95. What is the momentum of a photon having frequency $1.5 \times 10^{13} Hz$
a) $3.3 \times 10^{-29} kg\ m/s$ b) $3.3 \times 10^{-34} kg\ m/s$
c) $6.6 \times 10^{-34} kg\ m/s$ d) $6.6 \times 10^{-30} kg\ m/s$

96. A particle which has zero rest mass and non-zero energy and momentum, must travel with a speed
a) Equal to c, the speed of light in vacuum
b) Greater than c
c) Less than c
d) Tending of infinity

97. A proton and an α-particle are accelerated through same potential difference. The ratio of their de-Broglie wavelengths λ_p/λ_α will be
a) $\frac{1}{\sqrt{8}}$ b) $\sqrt{8}$
c) 2 d) 1

98. The de-Broglie wavelength associated with a particle moving with momentum (p) and mass (m) is
a) $\frac{h}{p}$ b) $\frac{h}{mp}$
c) $\frac{h}{p^2}$ d) $\frac{h^2}{p^2}$

99. An X-ray machine is operated at 40 kV. The short wavelength limit of continuous X-rays will be $(h = 6.63 \times 10^{-34} Js, c = 3 \times 10^8\ ms^{-1}, e = 1.6 \times 10^{-19}\ C)$
a) 0.31Å b) 0.62Å
c) 0.155Å d) 0.62Å

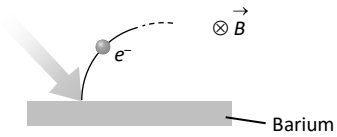
100. The threshold frequency for a metallic surface corresponds to an energy of 6.2 eV and the stopping potential for a radiation incident on this surface is 5V. The incident radiation lies in
a) Ultra-violet region b) Infra-red region
c) Visible region d) X-ray region

101. The wavelength of K_α line in copper is 1.54 Å. The ionization energy of K electron in copper in $Joule$ is
a) 11.2×10^{-27} b) 12.9×10^{-16}
c) 1.7×10^{-15} d) 10×10^{-16}

102. Nuclear radii may be measured by scattering high energy electrons from nuclei. What is the de-Broglie wavelength for 200 MeV electrons?
a) 8.28 fm b) 7.98 fm
c) 6.45 fm d) 6.20 fm

103. In vacuum an electron of energy 10 keV hits tungsten target, then emitted radiation will be
a) Cathode rays b) X-rays
c) Infrared rays d) Visible spectrum

104. Light of wavelength 2475 Å is incident on barium. Photoelectrons emitted describe a circle of radius 100 cm by a magnetic field of flux density $\frac{1}{\sqrt{17}} \times 10^{-5} Tesla$. Work function of the barium is (Given $\frac{e}{m} = 1.7 \times 10^{11}$)



a) 1.8 eV b) 2.1 eV
c) 4.5 eV d) 3.3 eV

105. A charged particle of mass m and charge q is released from rest in an uniform electric field E neglecting the effect of gravity, the kinetic energy of the charged particle after t second is

a) $\frac{2E^2t^2}{mq}$ b) $\frac{Eq^2m}{2t^2}$
c) $\frac{Eqm}{t}$ d) $\frac{E^2q^2t^2}{2m}$

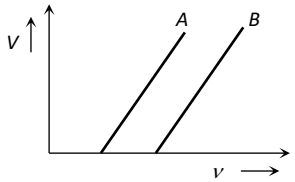
106. The energy of incident photons corresponding to maximum wavelength of visible light is

a) 3.2 eV b) 7 eV
c) 1.55 eV d) 1 eV

107. A uniform electric field and a uniform magnetic field exist in a region in the same direction. An electron is projected with a velocity pointed in the same direction. Then the electron will be

a) Be deflected to the left without increase in speed
b) Be deflected to the right without increase in speed
c) Not be deflected but its speed will decrease
d) Not be deflected but its speed will increase

108. The stopping potential as a function of the frequency of the incident radiation is plotted for two different photoelectric surfaces A and B. The graphs show that work function of A is



a) Grater than that of B
b) Smaller than that of B
c) Equal to that of B
d) No inference can be drawn about their work functions from the given graphs

109. The values $+\frac{1}{2}$ and $-\frac{1}{2}$ of spin quantum number show

a) Rotation of e^- clockwise and anticlockwise direction respectively
b) Rotation of e^- anticlockwise and clockwise directions respectively
c) Rotation in any direction according to convention
d) None of the above

110. In a photoelectric effect measurement, the stopping potential for a given metal is found to be V_0 volt when radiation of wavelength λ_0 is used. If radiation of wavelength $2\lambda_0$ is used with the same metal then the stopping potential (in volt) will be

a) $\frac{V_0}{2}$ b) $2V_0$
c) $V_0 + \frac{hc}{2e\lambda_0}$ d) $V_0 - \frac{hc}{2e\lambda_0}$

111. A metal block is exposed to beams of X-ray of different wavelengths X-rays of which wavelength penetrate most

a) 2 Å b) 4 Å
c) 6 Å d) 8 Å

112. Maximum velocity of photoelectron emitted is $4.8\,ms^{-1}$. The e/m ratio of electron is $1.76 \times 10^{11}\ Ckg^{-1}$, then stopping potential is given by

a) $5 \times 10^{-10}\ JC^{-1}$ b) $3 \times 10^{-7}\ JC^{-1}$
c) $7 \times 10^{-11}\ JC^{-1}$ d) $2.5 \times 10^{-2}\ JC^{-1}$

113. The continuous X-rays spectrum produced by an X-ray machine at constant voltage has

a) A maximum wavelength b) A minimum wavelength
c) A single wavelength d) A minimum frequency

114. In a photoelectric experiment, if both the intensity and frequency of the incident light are doubled, then the saturation photoelectric current

a) Remains constant b) Is halved
c) Is doubled d) Becomes four times

115. Monochromatic light of frequency f incident on emitter having threshold frequency f_0. The kinetic energy of ejected electron will be

a) hf b) $h(f - f_0)$
c) hf_0 d) $h(f + f_0)$

116. Which of the following supports the wave nature of X-rays?

a) Photoelectric effect b) Photosynthesis
c) Compton scattering d) Diffraction

117. Which of the following is incorrect statement regarding photon

a) Photon exerts no pressure b) Photon energy is hv
c) Photon rest mass is zero d) None of these

118. The velocity, v, at which the mass of a particle is double its rest mass is

a) $v = c$ b) $v = \sqrt{\frac{3}{4}}c$
c) $v = \sqrt{\frac{3}{2}}c$ d) $v = 2c$

119. Positive rays consists of

a) Electrons b) Neutrons
c) Positive ions d) Electro magnetic waves

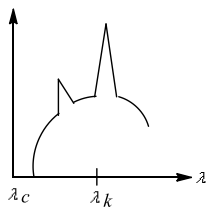
120. What is de-Broglie wavelength of electron having energy 10 ke V?

a) 0.12Å b) 1.2Å
c) 12.2Å d) None of these

121. The kinetic energy of an electron, which is accelerated in the potential difference of 100 V, is

a) 1.6×10^{-17} J b) 1.6×10^{-14} J
c) 1.6×10^{-10} J d) 1.6×10^{-8} J

122. The intensity of X-rays from a coolidge tube is plotted against wavelength λ as shown in figure. The minimum wavelength found is λ_c and the wavelength of K_α like is λ_K. As the accelerating voltage is increased



a) $\lambda_K - \lambda_c$ increases b) $\lambda_K - \lambda_c$ decreases
c) λ_K increases d) λ_K decreases

123. The maximum kinetic energy of emitted electrons in a photoelectric effect does not depend upon
a) Wavelength b) Frequency
c) Intensity d) Work function

124. Electron of mass m and charge e in external field E experiences acceleration
a) $\frac{e}{mE}$, in the opposite direction to the field
b) $\frac{eE}{m}$, in the direction of the field
c) $\frac{em}{E}$, in the direction of the field
d) $\frac{eE}{m}$,in the opposite direction of the field

125. The number of photons of wavelength 540 nm emitted per second by an electric bulb of power 100 W is (taking $h = 6 \times 10^{-34} J\text{-}s$)
a) 100 b) 1000
c) 3×10^{20} d) 3×10^{18}

126. In Thomson's method of determining e/m of electrons
a) Electric and magnetic fields are parallel to electrons beam
b) Electric and magnetic fields are parallel to each other and perpendicular to electrons beam
c) Magnetic field is parallel to the electrons beam
d) Electric field is parallel to the electrons beam

127. Which of the following is not the property of a cathode ray
a) It casts shadow b) It produces heating effect
c) It produces flurosence d) It does not deflect in electric field

128. The work function of a metal is 1eV. Light of wavelength 3000 Å is incident on this metal surface. The velocity of emitted photoelectrons will be
a) $10\ ms^{-1}$ b) $10^3\ ms^{-1}$
c) $10^4\ ms^{-1}$ d) $10^6\ ms^{-1}$

129. Maximum velocity of the photoelectrons emitted by a metal surface is $1.2 \times 10^6\ ms^{-1}$. Assuming the specific charge of the electron to be $1.8 \times 10^{11}\ C\ kg^{-1}$, the value of the stopping potential in volt will be
a) 2 b) 3
c) 4 d) 6

130. Compton effect shows that
a) X-rays are waves b) X-rays have high energy
c) X-rays can penetrate matter d) Photons have momentum

131. From the following, what charges can be present on oil drops in Millikan's experiment (Here e is the electronic charge)
a) Zero, equal to the magnitude of charge on α −particle
b) $2e, 1.6 \times 10^{-18} C$
c) $1.6 \times 10^{-19} C, 2.5e$
d) $1.5e, e$

132. An electric field of intensity $6 \times 10^4\ Vm^{-1}$ is applied perpendicular to the direction of motion of the electron. A magnetic field of induction $8 \times 10^{-2}\ Wm^{-2}$ is applied perpendicular to both the electric field and direction of motion of the electron. What is the velocity of the electron if it passes undeflected?
a) $7.5 \times 10^5\ ms^{-1}$ b) $7.5 \times 10^{-5}\ ms^{-1}$
c) $48 \times 10^{-2}\ ms^{-1}$ d) It is never possible

133. A photo-cell employs photoelectric effect to convert
   a) Change in the intensity of illumination into a change in the work function of the photo cathode
   b) Change in the frequency of light into a change in the electric current
   c) Change in the frequency of light into a change in electric voltage
   d) Change in the intensity of illumination into a change in photoelectric current

134. An electron is accelerated through a potential difference of 45.5 V.The velocity acquired by it is (in ms^{-1})
   a) 10^6 b) Zero
   c) 4×10^6 d) 4×10^4

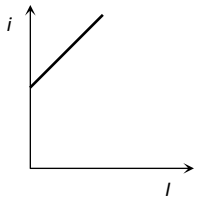
135. In producing X-rays a beam of electrons accelerated by a potential difference V is made to strike a metal target. For what value of V, X-rays will have the lowest wavelength of 0.3094 Å
   a) $10\ kV$ b) $20\ kV$
   c) $30\ kV$ d) $40\ kV$

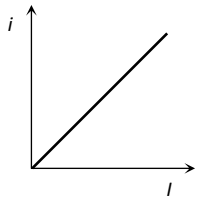
136. λ_e, λ_p and λ_α are the de Broglie wavelengths of electron, proton and α particle. If all are accelerated by same potential, then
   a) $\lambda_e < \lambda_p < \lambda_\alpha$ b) $\lambda_e < \lambda_p > \lambda_\alpha$
   c) $\lambda_e > \lambda_p < \lambda_\alpha$ d) $\lambda_e > \lambda_p > \lambda_\alpha$

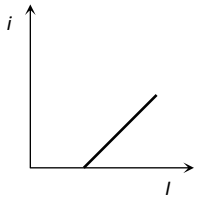
137. According to Einstein's photoelectric equation, the graph of KE of the photoelectron emitted from the metal versus the frequency of the incident radiation gives a straight line graph, whose slope
   a) Depends on the intensity of the incident radiation
   b) Depends on the nature of the metal and also on the intensity of incident radiation
   c) Is same for all metals and independent of the intensity of the incident radiation
   d) Depends on the nature of the metal

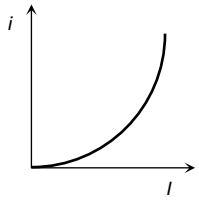
138. What is the de-Broglie wavelength (in Å) of the α-particle accelerated through a potential difference V?
   a) $\frac{0.287}{\sqrt{V}}$ b) $\frac{12.27}{\sqrt{V}}$
   c) $\frac{0.101}{\sqrt{V}}$ d) $\frac{0.22}{\sqrt{V}}$

139. The graph between intensity of light falling on a metallic plate (I) with the current (i) generated is

a) 

b) 

c) 

d) 

140. A beam of electrons of velocity $3 \times 10^7\ ms^{-1}$ is deflected 1.5 mm is passing 10 cm through an electric field of 1800 Vm^{-1} perpendicular to their path. The value of e/m for electron is
   a) $1.78 \times 10^{11}\ Ckg^{-1}$ b) $2 \times 10^{11}\ Ckg^{-1}$
   c) $1.5 \times 10^{11}\ Ckg^{-1}$ d) $3.5 \times 10^{11}\ Ckg^{-1}$

141. The photoelectric threshold wavelength for silver is λ_0. The energy of the electron ejected from the surface of silver by an incident wavelength λ $(\lambda < \lambda_0)$will be

a) $hc(\frac{\lambda_0-\lambda}{\lambda\lambda_0})$ b) $\frac{h}{c}(\frac{\lambda_0-\lambda}{\lambda\lambda_0})$

c) $\frac{hc}{\lambda_0-\lambda}$ d) $hc(\lambda_0-\lambda)$

142. Ultraviolet radiation of 6.2 eV falls on an aluminium surface (work function 4.2 eV). The kinetic energy of the faster electron emitted is approximately

a) 3.2×10^{-15} J b) 3.2×10^{-17} J

c) 3.2×10^{-19} J d) 3.2×10^{-21} J

143. An X-ray tube produces a continuous spectrum of radiation with its shortest wavelength of $45 \times 10^{-2} A$.

The maximum energy of a photon in the radiation in eV is $(h = 6.62 \times 10^{-34}$ Js , $c = 3 \times 10^8\ ms^{-1})$

a) 27500 b) 22500

c) 17500 d) 12500

144. The time taken by a photoelectron to come out after the photon strikes is approximately

a) $10^{-4}s$ b) $10^{-10}\ s$

c) $10^{-16}s$ d) $10^{-1}s$

145. Which of the following law is used in the Millikan's method for the determination of charge

a) Ampere's law b) Stoke's law

c) Fleming's left hand rule d) Fleming's right hand rule

146. When the speed of electrons increase, then the value of its specific charge

a) Increases

b) Decreases

c) Remains unchanged

d) Increases upto some velocity and then begins to decrease

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

a) Less than 40 keV b) More than 40 keV

c) Equal to 40 keV d) $\geq 40\ keV$

148. Bragg's equation will have no solution is

a) $\lambda > 2d$ b) $\lambda < 2d$

c) $\lambda < d$ d) $\lambda = d$

149. An electron in the hydrogen atom jumps excited state n to the ground state. The wavelength so emitted illuminates a photosensitive material having work function 2.75 eV. If the stopping potential of the photoelectron is 10 eV, then the value of n is

a) 5 b) 2

c) 3 d) 4

150. If the momentum of an electron is changed by Δp, then the de-Broglie wavelength associated with it changes by 0.50%. The initial momentum of the electron will be

a) $\frac{\Delta p}{200}$ b) $\frac{\Delta p}{199}$

c) $199\ \Delta p$ d) $400\ \Delta p$

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

a) The photo current will increase

b) The kinetic energy of the electrons will increase

c) The stopping potential will decrease

d) The threshold wavelength will increase

152. A light having wavelength 300 nm falls on a metal surface. Work function of metal is 2.54 eV. What is stopping potential?
a) 2.3 V b) 2.59 V
c) 1.60 V d) 1.29 V

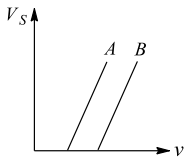
153. Stopping potential required to reduce the photoelectric current to zero
a) Is directly proportional to the wavelength of the incident radiation
b) Increases uniformly with wavelength of the incident radiation
c) Is directly proportional to the frequency of the incident radiation
d) Decreases uniformly with the frequency of the incident radiation

154. If the momentum of a photon is p, then its frequency is
Where m is the rest mass of the photon
a) $\frac{ph}{c}$ b) $\frac{pc}{h}$
c) $\frac{mh}{c}$ d) $\frac{mc}{h}$

155. The ratio of the de-Broglie wavelength of an α-particle and a proton of same kinetic energy is
a) 1:2 b) 1:1
c) $1:\sqrt{2}$ d) 4:1

156. X-rays of $\lambda = 1\text{Å}$ have frequency
a) $3 \times 10^{8} Hz$ b) $3 \times 10^{18} Hz$
c) $3 \times 10^{10} Hz$ d) $3 \times 10^{15} Hz$

157. When the photons of energy hv fall on a photosensitive metallic surface (work function hv_0) electrons are emitted from the metallic surface. The electrons coming out of the surface have some kinetic energy. The most energetic ones have the kinetic energy equal to



a) Less b) More
c) Equal d) Nothing can be said

158. The specific charge for positive rays is much less than that for cathode rays. This is because
a) Masses of positive rays are much larger
b) Charge on positive ray is less
c) Positive rays are positively charged
d) Experimental method is wrong

159. The filament current in the electron gun of a coolidge tube is increased while the potential difference used to accelerate the electrons is decreased. As a result, in the emitted radiation
a) The intensity increases while the minimum wavelength decreases
b) The intensity decreases while the minimum wavelength increases
c) The intensity as well as the minimum wavelength increases
d) The intensity as well as the minimum wavelength decreases

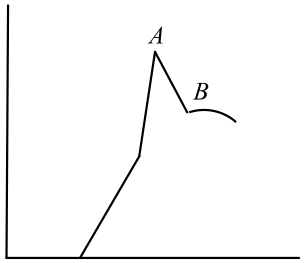
160. An electron initially at rest, is accelerated through a potential difference of 200 $volt$, so that it acquires a velocity $8.4 \times 10^{6} m/s$. The value of e/m of electron will be
a) $2.76 \times 10^{12} C/kg$ b) $1.76 \times 10^{11} C/kg$
c) $0.76 \times 10^{12} C/kg$ d) None of these

161. When yellow light is incident on a surface, no electrons are emitted while green light can emit. If red light is incident on the surface, then
a) No electrons are emitted
b) Photons are emitted
c) Electrons of higher energy are emitted
d) Electrons of lower energy are emitted

162. An electron of mass m and charge e initially at rest gets accelerated by a constant electric field E. The rate of change of de-Broglie wavelength of this electron at time t ignoring relativistic effects is
a) $\frac{-h}{eEt^2}$
b) $\frac{-e\,Et}{E}$
c) $\frac{-mh}{e\,Et^2}$
d) $\frac{-h}{e\,E}$

163. Calculate the energy of a photon with momentum $3.3 \times 10^{-13}\ kg\text{-}ms^{-1}$, given Planck's constant to be 6.6×10^{-34} Js
a) $7.3 \times 10^4\ J$
b) $9.9 \times 10^{-5}\ J$
c) $1.3 \times 10^5\ J$
d) $8.1 \times 10^3\ J$

164. Sharp peak point A represents



a) Characteristic X-ray
b) Continuous X-ray
c) Bremsstrahlung
d) Discontinuous spectrum

165. In Milikan's experiment, an oil drop having charge q gets stationary on applying a potential difference V in between two plates separated by a distance $'d'$. The weight of the drop is
a) qVd
b) $q\frac{d}{V}$
c) $\frac{q}{Vd}$
d) $q\frac{V}{d}$

166. A photon and electron have same de-Broglie wavelength. Give that v is the speed of electron and c is the velocity of light. E_e, E_p are the kinetic energy of electron and photon respectively. p_e, p_h are the momentum of electron and photon respectively. Then which of the following relation is correct?
a) $\frac{E_e}{E_p} = \frac{v}{2c}$
b) $\frac{E_e}{E_p} = \frac{2c}{v}$
c) $\frac{p_e}{p_h} = \frac{c}{2v}$
d) $\frac{p_e}{p_h} = \frac{2c}{v}$

167. Penetrating power of X-rays does not depend on
a) Wavelength
b) Energy
c) Potential difference
d) Current in the filament

168. Cathode rays and canal rays produced in a certain discharge tube are deflected in the same direction if
a) A magnetic field is applied normally
b) An electric field is applied normally
c) An electric field is applied tangentially
d) A magnetic field is applied tangentially

: ANSWER KEY :

1)	b	2)	a	3)	b	4)	d	5)	d	6)	c	7)	c	8)	b
9)	c	10)	b	11)	d	12)	c	13)	c	14)	b	15)	a	16)	c
17)	c	18)	a	19)	b	20)	c	21)	b	22)	c	23)	d	24)	a
25)	b	26)	c	27)	c	28)	c	29)	c	30)	c	31)	d	32)	a
33)	b	34)	a	35)	d	36)	b	37)	d	38)	a	39)	d	40)	b
41)	c	42)	a	43)	b	44)	c	45)	c	46)	c	47)	b	48)	c
49)	c	50)	c	51)	c	52)	d	53)	b	54)	c	55)	c	56)	a
57)	c	58)	d	59)	c	60)	d	61)	c	62)	d	63)	b	64)	c
65)	b	66)	B	67)	b	68)	b	69)	b	70)	b	71)	d	72)	b
73)	d	74)	b	75)	a	76)	d	77)	c	78)	b	79)	c	80)	a
81)	a	82)	c	83)	a	84)	c	85)	c	86)	d	87)	c	88)	d
89)	d	90)	c	91)	c	92)	a	93)	b	94)	d	95)	a	96)	a
97)	b	98)	a	99)	a	100)	a	101)	b	102)	d	103)	b	104)	c
105)	d	106)	c	107)	c	108)	b	109)	c	110)	d	111)	a	112)	c
113)	b	114)	c	115)	b	116)	d	117)	a	118)	b	119)	c	120)	a
121)	a	122)	a	123)	c	124)	a	125)	c	126)	b	127)	d	128)	d
129)	c	130)	d	131)	b	132)	a	133)	d	134)	c	135)	d	136)	d
137)	c	138)	c	139)	b	140)	c	141)	a	142)	c	143)	a	144)	b
145)	b	146)	b	147)	a	148)	a	149)	d	150)	c	151)	b	152)	c
153)	c	154)	b	155)	a	156)	b	157)	a	158)	a	159)	c	160)	b
161)	a	162)	a	163)	b	164)	a	165)	d	166)	a	167)	d	168)	a

: HINTS AND SOLUTIONS :

1 **(b)**

Given, the linear momentum of particle (p)

$= 2.2 \times 10^4 \text{kg} - \text{ms}^{-1}$

$\text{h} = 6.6 \times 10^{-34}$ JS

The de-Broglie wavelength of particle

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

$$\lambda = \frac{6.6 \times 10^{-34}}{2.2 \times 10^4}$$

Or $\lambda = 3 \times 10^{-38}$ m

Or $\lambda = 3 \times 10^{-29}$ mm

2 **(a)**

$\text{K}_{\text{max}} = \text{hv} - \text{hv}_0 = \frac{\text{hc}}{\lambda} - \frac{\text{hc}}{\lambda_0}$, i. e., graph between K_{max} and $\frac{1}{\lambda}$ will be straight line having slope (hc) and intercept $\frac{\text{hc}}{\lambda_0}$ on $-$KE axis

3 **(b)**

Wave nature of matter of de Broglie was proved when accelerated electrons showed diffraction by metal foil in the same manner as X-ray diffraction

4 **(d)**

Planck's constant,

$h = E/v = [ML^2T^{-2}/T^{-1}] = [ML^2T^{-1}]$

Angular momentum, $L = I\omega = [ML^2T^{-1}]$

5 **(d)**

From the symmetry of figure, the angle $\theta = 45°$. The path of moving proton in a normal magnetic field is circular. If r is the radius of the circular path, then from the figure,

$AC = 2\,r\,cos\,45° = 2r \times \frac{1}{\sqrt{2}} = \sqrt{2}r$ ...(i)

As $B\,q\,V = \frac{mv^2}{r}$ or $r = \frac{mv}{Bq}$

$$AC = \frac{\sqrt{2}\,mv}{B\,q} = \frac{\sqrt{2} \times 1.67 \times 10^{-27} \times 10^7}{1 \times 1.6 \times 10^{-19}} = 0.14\,m$$

6 **(c)**

Energy of photon

$$E = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{590 \times 10^{-9}} = \frac{6.63 \times 3}{59} \times 10^{-18}$$

Light energy produced per second $= \frac{90}{100} \times 10 = 9\text{W}$

$\therefore$ Number of photons emitted per sec

$$= \frac{9 \times 59}{6.63 \times 3 \times 10} - 18 = 2.67 \times 10^{19}$$

7 **(c)**

Momentum $p = \frac{E}{c} \Rightarrow E^2 = p^2c^2$

$$= \frac{12375}{4100} = 3.01\,eV$$

Work functions of metal A and B are less than $3.01eV$, so A and B will emit photo electrons

8 **(b)**

Unchanged

9 **(c)**

Work function $W_0 = hv_0 = 6.6 \times 10^{-34} \times 1.6 \times 10^{15}$

$= 1.056 \times 10^{-18} J = 6.6\ eV$

From $E = W_0 + K_{max} \Rightarrow K_{max} = E - W_0 = 1.4\ eV$

10 **(b)**

KE of fastest electron

$= E = \phi_0 = 6.2 - 4.2 = 2.0\ eV$

$= 2 \times 1.6 \times 10^{-19} = 3.2 \times 10^{-19}\ J$

11 **(d)**

$\Delta\lambda = \lambda_{K_\alpha} - \lambda_{min}$ When V is halved λ_{min} becomes two time but λ_{K_α} remains the same.

$\therefore \Delta\lambda' = \lambda_{K_\alpha} - 2\lambda_{min} = 2(\Delta\lambda) - \lambda_{K_\alpha}$

$\therefore \Delta\lambda' < 2(\Delta\lambda)$

12 **(c)**

Among the given metals, aluminium thermionically emits an electron at a relatively lowest temperature

13 **(c)**

According to J. J. Thomson's cathode ray tube experiment the e/m of electrons is much greater than thee/m of protons.

14 **(b)**

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

15 **(a)**

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

16 **(c)**

Speed of the cathode rays is $10^7 m/sec - 3 \times 10^7 m/s$

17 **(c)**

Specific charge on proton $=\left(\frac{e}{m}\right)_p$

$=9.6 \times 10^7 C - kg^{-1}$ specific charge on α- particle,

$$\left(\frac{q}{m}\right)_\alpha = \frac{2e}{4m} = \frac{1}{2}\left(\frac{e}{m}\right)_p = \frac{1}{2} \times 9.6 \times 10^7$$

$= 4.8 \times 10^7\ C - kg^{-1}$

18 **(a)**

If an electron and a proton propagating in the form of waves and their wavelength are same, then according to the relation

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

Also, $\lambda_{electron} = \lambda_{proton}$

$\therefore\ E_e = E_p$

Hence, their energies are same.

19 **(b)**

In the presence of inert gas photoelectrons emitted by cathode ionize the gas by collision and hence the current increases

20 **(c)**

Having all wavelengths larger than a certain minimum wavelength

21 **(b)**

If an electron and a photon propagates in the form of waves having the same wavelength, it implies that they have same momentum. This is according to de-Broglie equation

$p \propto \frac{1}{\lambda}$

22 **(c)**

$\lambda_{min} = \frac{12375}{50 \times 10^3} Å = 0.247 = 0.25Å$

23 **(d)**

de-Broglie wavelength

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

$\therefore \frac{\lambda_1}{\lambda_2} = \sqrt{\frac{E_2}{E_1}} \Rightarrow \frac{1 \times 10^{-9}}{0.5 \times 10^{-9}} = \sqrt{\frac{E_2}{E_1}}$

$\Rightarrow 2 = \sqrt{\frac{E_2}{E_1}} \Rightarrow \frac{E_2}{E_1} = 4$

$\therefore E_2 = 4E_1$

$\therefore$ Energy to be added $= E_2 - E_1$

$= 4E_1 - E_1 = 3E_1$

24 **(a)**

$E = hv$

25 **(b)**

$q\,V = \frac{1}{2}mv^2$ or $v = \sqrt{2qV/m}$ $ie, v \propto \sqrt{V}$

26 **(c)**

Stopping potential $= 1.8eV - 1.2eV = 0.6\ eV$

27 **(c)**

$E \propto \frac{1}{\lambda} \Rightarrow \frac{2.5}{E'} = \frac{1}{5000} \Rightarrow E' = (2.5) \times 5000\ eV$

28 **(c)**

$\phi_0 = hc/\lambda_0$ (in eV)

$= \frac{6.62 \times 10^{-34} \times 3 \times 10^8}{5420 \times 10^{-10} \times 1.6 \times 10^{-19}} = 2.29\ eV$

29 **(c)**

$9.1 \times 10^{-31} kg$

30 **(c)**

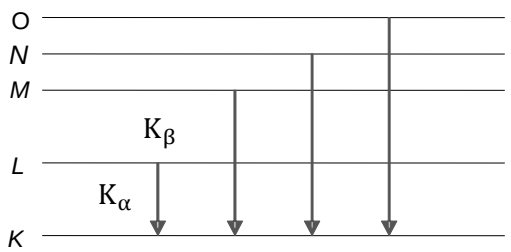
When current in X-ray tube is increased, then the number of electrons striking the anticathode increases which in turn increases the intensity of X-rays

31 **(d)**

Cathode rays are beam of electrons

32 **(a)**

When the colliding electron remove an electron from innermost k-shell (corresponding to n=1) of atom and electron from some higher shell jumps to k-shell to fill up this vacancy, characteristic X-ray of k- series are obtained



K- Series

$\therefore K_\propto$ and K_β X-rays are emitted when there is transition of electron between the levels n=2 to n=1 and n=3 to n=1 respectively.

33 **(b)**

Number of photons emitted is proportional to the intensity. Also $\frac{hc}{\lambda} = W_0 + E$

34 **(a)**

Energy of the electron, when it comes out from the second plate $= 200\ eV - 100\ eV = 100\ eV$

Hence accelerating potential difference $= 100\ V$

$$\lambda_{Electron} = \frac{12.27}{\sqrt{V}} = \frac{12.27}{\sqrt{100}} = 1.23\text{Å}$$

35 **(d)**

Given : $E = 13.2keV$

$$\lambda(in\ \text{Å}) = \frac{hc}{E(eV)} = \frac{12400}{13.2 \times 10^3} = 0.939\text{Å} = 1\text{Å}$$

X-rays covers wavelengths ranging from about $10^{-8}m(10nm)$ to $10^{-3}m(10^{-4}nm)$.

An electromagnetic radiation of energy 13.2 keV belongs to X-ray region of electromagnetic spectrum

36 **(b)**

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

37 **(d)**

$$hv - W_0 = \frac{1}{2}mv_{max}^2 \Rightarrow \frac{hc}{\lambda} - \frac{hc}{\lambda_0} = \frac{1}{2}mv_{max}^2$$

$$\Rightarrow hc\left(\frac{\lambda_0 - \lambda}{\lambda\lambda_0}\right) = \frac{1}{2}mv_{max}^2 \Rightarrow v_{max} = \sqrt{\frac{2hc}{m}\left(\frac{\lambda_0 - \lambda}{\lambda\lambda_0}\right)}$$

When wavelength is λ and velocity is v, then

$$v = \sqrt{\frac{2hc}{m}\left(\frac{\lambda_0 - \lambda}{\lambda\lambda_0}\right)} \qquad \ldots(i)$$

When wavelength is $\frac{3\lambda}{4}$ and velocity is v' then

$$v' = \sqrt{\frac{2hc}{m}\left[\frac{\lambda_0 - (3\lambda/4)}{(3\lambda/4) \times \lambda_0}\right]} \qquad \ldots(ii)$$

Divide equation (ii) by (i), we get

$$\frac{v'}{v} = \sqrt{\frac{[\lambda_0 - (3\lambda/4)]}{\frac{3}{4}\lambda\lambda_0} \times \frac{\lambda\lambda_0}{\lambda_0 - \lambda}}$$

$$\text{v}' = v\left(\frac{4}{3}\right)^{1/2}\sqrt{\frac{[\lambda_0 - (3\lambda/4)]}{\lambda_0 - \lambda}}$$

$$i.e.\ v' > v\left(\frac{4}{3}\right)^{1/2}$$

38 **(a)**

$$\lambda_{min} = \frac{12375}{40 \times 10^3} = 0.309\ \text{Å} \approx 0.31\ \text{Å}$$

39 **(d)**

According to Einstein's equation

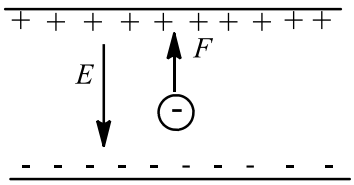
$$hv = W_o + K_{max} \Rightarrow V_o = \left(\frac{h}{e}\right)v - \frac{W_o}{e}$$

This is the equation of straight line having positive slope (h/e) and intercept on $-V_o$ axis, equal to $\frac{W_o}{e}$

40 **(b)**

Electric force (F) is straight forwarded, given by

$F = qE$



Where, q is charge and E is electric field.

Given, $q = 3e$

$\therefore$ F=3eE ...(i)

From Newton's law, force experienced by a particle of mass 2m witn acceleration a is

$$F = 2ma \ldots.(ii)$$

Equating Eqs. (i) and (ii) we get

$3eE = 2ma$

$\Rightarrow a = \dfrac{3eE}{2m}$

41 **(c)**

Bombardment of high energy electron on heavy metal

42 **(a)**

$qvB = qE \Rightarrow v = \dfrac{E}{B}$

But $\frac{1}{2}mv^2 = qV$ so $\frac{q}{m} = \frac{v^2}{2V} = \frac{E^2}{2VB^2}$

43 **(b)**

When the charged particle enters the magnetic field making angle other than 90^0 with it, the path is helix.

44 **(c)**

$n \rightarrow 2 - 1$

$E = 10.2\ eV$

$kE = E - \phi$

$Q = 10.20 - 3.57$

$hv_0 = 6.63\ eV$

$v_0 = \dfrac{6.63 \times 1.6 \times 10^{-19}}{6.67 \times 10^{-34}} = 1.6 \times 10^{15}$

45 **(c)**

According to Mosley's law $v = a(Z - b)^2$ and $v \propto \frac{1}{\lambda}$

46 **(c)**

$QE = mg \Rightarrow Q = \dfrac{mg}{E} \Rightarrow n = \dfrac{mgd}{Ve}$

$\Rightarrow n = \dfrac{1.8 \times 10^{-14} \times 10 \times 0.9 \times 10^{-2}}{2 \times 10^3 \times 1.6 \times 10^{-19}} = 5$

47 **(b)**

Energy possessed by a photon is given by

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

If power of each photon is P then energy given out in t second is equal to Pt. Let the number of photons be n, then

$n = \frac{Pt}{E} = \frac{Pt}{(hc/\lambda)} = \frac{Pt\lambda}{hc}$

For red light, $n_R = \frac{Pt\lambda_R}{hc}$

For violet light, $n_V = \frac{Pt\lambda_V}{hc}$

$\therefore \frac{n_R}{n_V} = \frac{\lambda_R}{\lambda_V}$

As $\lambda_R > \lambda_V$

So, $n_R > n_V$

48 **(c)**

Electromagnetic radiantions of high frequency

49 **(c)**

$\lambda = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2m_\alpha Q_\alpha V}}$

On putting $Q_\alpha = 2 \times 1.6 \times 10^{-19} C$

$m_\alpha = 4m_p = 4 \times 1.67 \times 10^{-27} kg \Rightarrow \lambda = \frac{0.101}{\sqrt{V}}$ Å

50 **(c)**

$m = \frac{m_0}{\sqrt{1 - v^2/c^2}} = \frac{m_0}{\sqrt{1 - (0.8c)^2/c^2}} = \frac{5m_0}{3}$

51 **(c)**

$W_0 \propto \frac{1}{\lambda} \Rightarrow \frac{\lambda_1}{\lambda_2} = \frac{(W_0)_2}{(W_0)_1} = \frac{4.5}{2.3} = \frac{2}{1}$

52 **(d)**

Given, $m_\alpha = 6.4 \times 10^{-27} kg$

$q_\alpha = 3.2 \times 10^{-19}$ C, $E = 1.6 \times 10^5\ Vm^{-1}$

Force on α-particle

$F = q_\alpha F = 3.2 \times 10^{-19} \times 1.6 \times 10^5$

$= 51.2 \times 10^{-15}$N

Now, acceleration of the particle

$\alpha = \frac{F}{m_\alpha} = \frac{51.2 \times 10^{-15}}{6.4 \times 10^{-27}} = 0.8 \times 10^{13}\ ms^{-2}$

$\because Initial\ velocity, \quad u = 0$

$\therefore \ v^2 = 2\alpha s$

$= 2 \times 8 \times 10^{12} \times 2 \times 10^{-2} = 32 \times 10^{10}$

or $v = 4\sqrt{2} \times 10^5 ms^{-1}$

53 **(b)**

From the graph stopping potential $|V_s| = -V$

Also $k_{max} = (|V_0|)eV = 4eV$

54 **(c)**

When applied voltage is greater then enrgy of K-electron, continuous and all characteristic X-rays are emitted

55 **(c)**

de-Broglie wavelength

Here $\lambda_e = \frac{h_c}{\sqrt{2m_e E}}$ and $\lambda_p = \frac{h_c}{\sqrt{2m_p E}}$

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

56 **(a)**

Because X-rays are electromagnetic (Neutral) in nature

57 **(c)**

$$\lambda = \frac{h}{\sqrt{2mQV}} \Rightarrow \lambda \propto \frac{1}{\sqrt{mQ}} \Rightarrow \frac{\lambda_p}{\lambda_\alpha} = \sqrt{\frac{m_\alpha Q_\alpha}{m_p Q_p}}$$

$$= \sqrt{\frac{4m_p \times 2Q_p}{m_p \times Q_p}} = 2\sqrt{2}$$

58 **(d)**

In a discharge tube ionization of enclosed gas is produced due to collisions between negative electrons and neutral atoms/molecules

59 **(c)**

Comparing Einstein's equation $K_{max} = hv - hv_0$, with $y = mx + c$, we get slope, $m = h$

60 **(d)**

$$E_k = \frac{hc}{\lambda} - \frac{hc}{\lambda_0} = hc\left[\frac{\lambda_0 - \lambda}{\lambda_0 \lambda}\right]$$

61 **(c)**

Given, $\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mKE}}$

$\Rightarrow KE = \frac{1}{2m\lambda^2}$

As λ is same for both electron and photon

So, $KE \propto \frac{1}{m}$

Hence, kinetic energy will be maximum for particle with lesser mass, *ie*, electron.

62 **(d)**

By law of conservation of linear momentum

$m_1 v_1 = m_2 v_2$

So, $m_1 v_1 = m_2 v_2$

Now, de-Broglie wavelength $\lambda = \frac{h}{mv}$

$\therefore \frac{\lambda_1}{\lambda_2} = \frac{m_2 v_2}{m_1 v_1}$

$\lambda_1 : \lambda_2 = 1 : 1$

63 **(b)**

According to Bohr's quantisation of angular momentum

$$mvr = \frac{nh}{2\pi}$$

Or $\frac{h}{mv} = \frac{2\pi r}{n} \quad ..(i)$

de-Broglie wavelength

$\lambda = \frac{h}{mv} \quad ..(ii)$

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

Wavelength $\lambda = \frac{2\pi r}{n}$

$= \frac{2 \times \pi \times 0.53\ \text{Å}}{1} = 3.33\text{Å}$

64 **(c)**

It was found that when voltage applied to X-ray tube is changed, positions of spectral lines remain unchanged. However, when a different material is used as a target in X-ray tube, an entirely different set of spectral lines is obtained. Thus, the energy of characteristic X-ray is a consequence of transition in target atoms.

65 **(b)**

If intensity of X-ray is decreased by dl, when it passes through a length dx of absorbing material then, the amount of observed intensity is $\mu I\ dx$

Thus, $-dI = \mu I\ dx$ or $\frac{dI}{dx} + \mu I = 0$

On solving this equation $I = I_0 e^{-\mu x} = I_0 e^{-\mu d}$ $[x = d]$

66 **(b)**

The graph between stopping potential and frequency is a straight line, so stopping potential and hence, maximum kinetic energy of photoelectrons depends linearly on the frequency.

67 **(b)**

$$\lambda_0 = \frac{c}{v_0} = \frac{3 \times 10^8}{5 \times 10^{14}} = 6 \times 10^{-7} m = 6000\ \text{Å}$$

68 **(b)**

$$\lambda_{photon} = \frac{hc}{E}$$

and $\lambda_{electron} = \frac{h}{\sqrt{2mE}}$

$$\Rightarrow \frac{\lambda_{photon}}{\lambda_{electron}} = c\sqrt{\frac{2m}{E}}$$

$$\Rightarrow \frac{\lambda_{photon}}{\lambda_{electron}} \propto \frac{1}{\sqrt{E}}$$

69 **(b)**

$$\lambda_0 = \frac{12375}{6.825} = 1813\ \text{Å} = 1800\text{Å}$$

70 **(b)**

For $\phi = 90^0, cos\ \phi = 0$

So, $\lambda' = \lambda + \frac{h}{m_e c}$

$$= 0.140 \times 10^{-9} + \frac{6.63 \times 10^{-34}}{(9.1 \times 10^{-31})(3 \times 10^8)}$$

$$= (0.140 \times 10^{-9} + 2.4 \times 10^{-12})\ m = 0.142\ nm$$

71 **(d)**

$$\lambda = \frac{12375}{(40 \times 10^3)} = 0.309\text{Å} \approx 0.31\text{Å}$$

72 **(b)**

$E = 3eV = 3 \times 1.6 \times 10^{-19}$ J

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

$$= \frac{6.6 \times 10^{-34}}{\sqrt{2 \times 1.7 \times 10^{-27} \times 3 \times 1.6 \times 10^{-19}}} = 1.65 \times 10^{-11} m$$

73 **(d)**

All of the above

74 **(b)**

The potential difference across the filament and target determines the energy and hence the penetrating power of X-rays

75 **(a)**

$4 \times 10^3 = 10^{20} \times hf$

$$f = \frac{4\times10^3}{10^{20}\times6.023\times10^{-34}}$$

$$f = 6.64\times 10^{16}\ \text{Hz}$$

The obtained frequency lies in the band of X-rays.

76 **(d)**

Greater the number of electrons striking the anode, larger is the number of X-ray photons emitted

77 **(c)**

Speed of photon is $3 \times 10^8 m/s$ in vacuum

78 **(b)**

$\frac{1}{2}mv_1^2 = 2\phi_0 - \phi_0 = \phi_0$ and $\frac{1}{2}mv_2^2 = 10\phi_0 - \phi_0 = 9\phi_0$

$$\therefore\ \frac{v_1}{v_2} = \sqrt{\frac{\phi_0}{9\phi_0}} = \frac{1}{3}$$

79 **(c)**

Momentum, $p = mv = h/\lambda$

or $v = \frac{h}{m\lambda} = \frac{6.62\times10^{-34}}{9.1\times10^{-31}\times5.2\times10^{-7}}$

$= 1.4 \times 10^3\ ms^{-1} = 1400\ ms^{-1}$

80 **(a)**

Intensity of X-rays depends upon the number of electron striking the target

81 **(a)**

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

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

The nearest integer is 3.

82 **(c)**

$K = Q.V = 1e \times 1\ Volt = 1eV$

83 **(a)**

$$K_p = E_p - \phi_p = \frac{1240}{550} - 2.0 = 0.2545\ eV$$

$$K_q = E_q - \phi_q = \frac{1240}{450} - 2.5 = 0.255\ eV$$

$$K_r = E_r - \phi_r = \frac{1240}{350} - 3.0 = 0.543\text{eV}$$

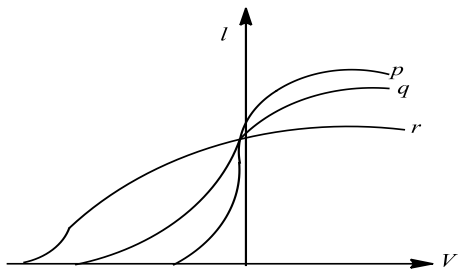
In the above equation K represents maximum kinetic energy of photoelectrons and E, the energy of incident right.

From the above values we can see that stopping potential,

$|V_r| > |V_q| > |V_p|$

Further, their intensities are equal, but energy of individual photon r is maximum. Hence, number of photons incident (per unit area per unit time) of r can be assumed to be least. Hence, saturation current of r should be minimum.

Keeping these points in mind no option seems to be correct. The correct graph is shown below



∴ No choice is correct.

84 **(c)**

Optical to electrical

85 **(c)**

Cathode ray oscilloscope

86 **(d)**

Einstein

87 **(c)**

$\lambda = \frac{h}{mv} \Rightarrow \lambda \propto \frac{1}{m}$

352 **(d)**

Photoelectric effect supports quantum nature of light because

1. There is minimum frequency of light below which no photoelectrons are emitted.
2. Maximum kinetic energy of photoelectrons depends only on the frequency of light and not on its intensity.
3. Even when metal surface is fainthy illuminated the photoelectrons leave the surface immediately.

88 **(d)**

1,3,4

89 **(d)**

Target should be of high atomic number and high melting point

90 **(c)**

Let E_1 and E_2 be the KE of photoelectrons for incident light of frequency v and $2v$ respectively.

Then $hv = E_1 + \phi$ and $h2v = E_2 + \phi_0$

So, $2(E_1 + \phi_0) = E_2 + \phi_0$ or $E_2 = 2E_1 + \phi_0$

It means the KE of photoelectron becomes more than double

91 **(c)**

Specific charge on proton $=\left(\frac{e}{m}\right)_p$

$= 9.6 \times 10^7 Ckg^{-1}$ specific charge on ∝-particle,

$\left(\frac{q}{m}\right)_\propto = \frac{2e}{4m} = \frac{1}{2}\left(\frac{e}{m}\right)_p = \frac{1}{2} \times 9.6 \times 10^7$

$= 4.8 \times 10^7\ Ckg^{-1}$

92 **(a)**

Using Einstein's equation, $V_0 = \left(\frac{h}{e}\right) v - \frac{W_0}{e}$

Comparing this equation with $y = mx + c$

We get intercept on $-V_0$ axis $= \frac{W_0}{e}$

$\Rightarrow OB = \frac{W_0}{e} \Rightarrow W_0 = OB \times e$

93 **(b)**

For one second, distance = Velocity = $3 \times 10^4 m/sec$ and $Q = i \times 1 = 10^{-6}C$. Charge density = $\frac{Charge}{Volume}$

$$= \frac{10^{-6}}{3 \times 10^4 \times 0.5 \times 10^{-6}} = 6.6 \times 10^{-5} C/m^3$$

94 **(d)**

From Einstein equation $E = W_0 + \frac{1}{2}mv^2$

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

and a charged particle placed in uniform magnetic field experience a force

$$F = \frac{mv^2}{r} \Rightarrow evB = \frac{mv^2}{r} \Rightarrow r = \frac{mv}{eB}$$

$$\Rightarrow r = \frac{\sqrt{2m(E - W_0)}}{eB}$$

95 **(a)**

$$p = \frac{hv}{c} = \frac{6.6 \times 10^{-34} \times 1.5 \times 10^{13}}{3 \times 10^8} = 3.3 \times 10^{-29} kg - m/s$$

96 **(a)**

Particle is photon and it travels with the velocity equal to light in vacuum

97 **(b)**

From relation $\lambda = \frac{h}{\sqrt{2mqV}}$ or $\lambda \propto \frac{1}{\sqrt{mq}}$

Hence, $\frac{\lambda_p}{\lambda_\alpha} = \sqrt{\frac{m_\alpha}{m_p} \times \frac{q_\alpha}{q_p}}$

$$= \sqrt{\frac{4m_p \times 2e}{m_p \times e}} = \sqrt{8}$$

98 **(a)**

de-Broglie wavelength associated with a moving particle

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

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

Where p is momentum of the particle.

99 **(a)**

For an accelerating voltage V, the maximum X-ray photon energy is given by

$hv_{max} = eV$

Also, $\gamma = \frac{c}{\lambda} = \frac{velocity\ of\ light}{wavelength}$

$$\therefore \quad \lambda_{min} = \frac{ch}{eV} = \frac{3 \times 10^8 \times 6.63 \times 10^{-34}}{1.6 \times 10^{-19} \times 40 \times 10^3}$$

$$= 0.31 \times 10^{-10}\ \text{m} \approx 0.31\ \text{A}$$

100 **(a)**

$hv_0 = 6.2\ eV, \qquad eV_0 = 5\ eV$

from Einstein's photoelectric equation

$hv = hv_0 + eV_0 = 6.2 + 5 = 11.2\ eV$

$$\Rightarrow \frac{hc}{\lambda} = 11.2$$

$$\therefore \lambda = \frac{hc}{11.2} = 1108.9\text{Å}$$

Which belongs to ultra-violet region.

101 **(b)**

Required ionisation energy

$$= \frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{1.54 \times 10^{-10}} J = 12.9 \times 10^{-16} J$$

102 **(d)**

The de-Broglie wavelength

$$\lambda = \frac{hc}{E} = \frac{1240}{200 \times 10^{6}}$$

$=6.20\times 10^{-6}$ nm $= 6.20$fm

103 **(b)**

When a high energy electron is incident on heavy metal, it produces X-rays

104 **(c)**

Radius of circular path described by a charged particle in a magnetic field is given by

$r = \frac{\sqrt{2mK}}{qB}$; where K = Kinetic energy of electron $\Rightarrow K = \frac{q^2B^2r^2}{2m} = \left(\frac{e}{m}\right)\frac{eB^2r^2}{2}$

$$= \frac{1}{2} \times 1.7 \times 10^{11} \times 1.6 \times 10^{-19} \times \left[\frac{1}{\sqrt{17}} \times 10^{-5}\right]^2 \times (1)^2$$

$$= 8 \times 10^{-20} J = 0.5\ eV$$

By using $E = W_0 + K_{max}$

$$\Rightarrow W_0 = E - K_{max} = \left(\frac{12375}{2475}\right) eV - 0.5\ eV = 4.5\ eV$$

105 **(d)**

Electrostatic force on charged particle

$$F = qE$$

So, by Newton's law of motion

$$F = ma = qE \text{ or } a = \frac{qE}{m}$$

Velocity attained by particle $v = 0 + \frac{qE}{m} t$

So, kinetic energy $K = \frac{1}{2}mv^2$

$$K = \frac{1}{2}\frac{mq^2E^2}{m^2} t^2 = \frac{E^2q^2t^2}{2m}$$

106 **(c)**

From Planck's hypothesis, the energy of a photon of frequency v is

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

Where c is speed of light and λ the wavelength.

In the visible part, red colour has maximum wavelength

$\lambda = 8000$ Å

$$\therefore E = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{8000 \times 10^{-10}}$$

Also, 1 eV$= 1.6\times 10^{-19}$ J

$$\therefore E = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{8000 \times 10^{-10} \times 1.6 \times 10^{-19}}$$

$= 1.547$ eV

107 **(c)**

As electron is moving parallel to both the fields, so magnetic force does not affect the electron's motion. But electric force (qE) acts opposite to motion of electron. Hence, electron will not be deflected but its speed decreases.

108 **(b)**

From the given graph it is clear that if we extend the given graph for A and B, intercept of the line A on V axis will be smaller as compared to line B means work function of A is smaller than that of B ific charge moving with different velocity lie on the same parabola

109 **(c)**

Rotation in any direction according to convention

110 **(d)**

From Einstein's photoelectric equation

$$eV_0 = \frac{hc}{\lambda_0} - W_0$$

$$eV' = \frac{hc}{2\lambda_0} - W_0$$

Subtracting $e(V_0 - V') = \frac{hc}{\lambda_0}\left[1 - \frac{1}{2}\right] = \frac{hc}{2\lambda_0}$

or $V' = V_0 - \frac{hc}{2e\lambda_0}$

111 **(a)**

Penetrating power is greater for lower wavelength

112 **(c)**

$$eV_s = \frac{1}{2}mv_m^2 \ or \ V_s = \frac{mv_m^2}{2e} = \frac{v_m^2}{2(e/m)}$$

$$= \frac{(4.8)^2}{2 \times 17.6 \times 10^{11}} = 7 \times 10^{11} \ JC^{-1}$$

113 **(b)**

Continuous spectrum of X-rays consists of radiations of all possible wavelength range having a definite short wavelength limit

114 **(c)**

The saturation photoelectric current is directly proportional to the intensity of incident radiation but it is independent of its frequency. Therefore, the saturation photoelectric current becomes double, when both intensity and frequency of the incident light are doubled

115 **(b)**

According to Einstein's photo electric equation,

Incident energy = work function + kinetic energy of emitted electron

$hf = hf_0 + K$

or $K = h(f - f_o)$

116 **(d)**

Diffraction

117 **(a)**

Photon exerts no pressure

118 **(b)**

Using Einstein's realtion for relativistic mass

$$m = \frac{m_0}{\sqrt{1 - V^2/C^2}} [m_0 = rest\ mass]$$

$$\Rightarrow \frac{m}{m_0} = \frac{1}{\sqrt{1 - V^2/C^2}}$$

Given $\frac{m}{m_0} = 2 = \frac{1}{\sqrt{1-V^2/C^2}}$

$$\Rightarrow 1 - \frac{V^2}{C^2} = \frac{1}{4} \Rightarrow \frac{V^2}{C^2} = \frac{3}{4}$$

$\Rightarrow \frac{V}{C} = \frac{\sqrt{3}}{2} \Rightarrow V = \frac{\sqrt{3}}{2}C$

119 **(c)**

Positive rays consist of positive ions

120 **(a)**

De-Broglie wavelength of a particle is given by

$\lambda = \frac{h}{mv}$ ...(i)

Where h is Planck's constant.

If kinetic energy of particle of mass m is v, then

$K = \frac{1}{2}mv^2$

$\Rightarrow v = \sqrt{\frac{2K}{m}}$...(ii)

Combining Eqs. (i) and (ii), we get

$\lambda = \frac{h}{m\sqrt{\frac{2K}{m}}} = \frac{h}{\sqrt{2mK}}$ ...(iii)

Given $m = 9.1 \times 10^{-31}$ kg

$K = 10keV = 10 \times 10^3 \times 1.6 \times 10^{-19}$ J

$h = 6.6 \times 10^{-34}$ J-s

Substituting the above values in Eq. (iii), we get

$\lambda = \frac{6.6 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 10 \times 10^3 \times 1.6 \times 10^{-19}}}$

$= 1.22 \times 10^{-11} \approx 0.12$Å

121 **(a)**

$KE = eV = 1.6 \times 10^{-19} \times 100 = 1.6 \times 10^{-17}$ J

122 **(a)**

As accelerating voltage V across X-rays tube increase, the value of minimum wavelength of X-rays, $\lambda_c = \frac{hc}{eV}$; decreases ; so the separation between λ_K and λ_c increases.

123 **(c)**

If the intensity of light incident on photosensitive metal surface is changed it does not affect the maximum kinetic energy of the emitted electrons.

124 **(a)**

$F = qE$

or $ma = eE$

$\Rightarrow a = \frac{qE}{m}$

or $a = \frac{eE}{m}$ in the opposite direction of the field.

125 **(c)**

$p = \frac{nhc}{\lambda t} \Rightarrow 100 = \frac{n \times 6 \times 10^{-34} \times 3 \times 10^8}{540 \times 10^{-9} \times 1} \Rightarrow n = 3 \times 10^{20}$

126 **(b)**

Electric and magnetic fields are parallel to each other and perpendicular to electrons beam

127 **(d)**

Cathode rays are steam of negatively charged particles, so they deflect in electric field

128 **(d)**

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

$$= \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{(3 \times 10^{-7}) \times 1.6 \times 10^{-19}} - 1$$

$$= 4.14 - 1 = 3.14eV$$

or $v = \sqrt{\frac{2 \times 3.14 \times 1.6 \times 10^{-19}}{9.1 \times 10^{-31}}} = 10^6 ms^{-1}$

129 **(c)**

Specific charge on electron,

$$\frac{e}{m} = 1.8 \times 10^{11}\ C\ Kg^{-1}$$

Maximum kinetic energy of photoelectron

$$\frac{1}{2}mv_{max}^2 = eV_s$$

Where V_s is the stopping potential.

$$\Rightarrow\ V_s = \frac{mv_{max}^2}{2e} = \frac{v_{max}^2}{2(e/m)}$$

$$= \frac{(1.2 \times 10^6)^2}{2 \times 1.8 \times 10^{11}}$$

$$= 0.4 \times 10 = 4V$$

130 **(d)**

Photons have momentum

131 **(b)**

In Milikan's experiment, the charges present on the oil drops are the integral multiples of electronic charge, so $2e$ and $10e(1.6 \times 10^{-18}C)$ charges are present

132 **(a)**

$v = E/\mathrm{B} = 6 \times 10^4/8 \times 10^{-2} = 7.5 \times 10^5 ms^{-1}$

133 **(d)**

The photoelectric current is directly proportional to the intensity of illumination. Therefore a change in the intensity of the incident radiation will change the photocurrent also

134 **(c)**

When electron is accelerated through a potential difference of V volts, then

Kinetic energy $-eV$

$$ie.\ \frac{1}{2}mv^2 = eV$$

$$\Rightarrow v = \sqrt{\left(\frac{2eV}{m}\right)}$$

$$\therefore v = \sqrt{\left(\frac{2 \times 1.6 \times 10^{-19} \times 45.5}{9.1 \times 10^{-31}}\right)}$$

$$= 4 \times 10^6\ ms^{-1}$$

135 **(d)**

From the formula

$$V = \frac{12375}{\lambda_{min}} = \frac{12375}{0.3094} = 39.99\ kV = 40\ kV$$

136 **(d)**

de Broglie wavelength

$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE}} \Rightarrow \lambda \propto \frac{1}{\sqrt{Em}}$

Now kinetic energy E gained by a charged particle under potential V is $E = qV$ given V is same for the given three paticles

$\therefore E_e = eV; E_p = eV$

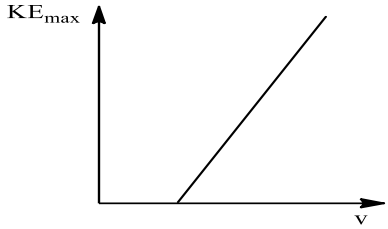
$E_\alpha = 2eV \Rightarrow E_e = E_p < E_\alpha$ and $m_e < m_p < m_\alpha$

$\Rightarrow \lambda = \frac{h}{\sqrt{2m_eE_e}} > \frac{h}{\sqrt{2m_pE_p}} > \frac{h}{\sqrt{2m_\alpha E_\alpha}}$

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

137 **(c)**

According to Einstein's photoelectric equation



$KE_{max} = hv - \phi_0$

Comparing with the equation of straight line

$y = mx + c$

We get, slope of graph = h

138 **(c)**

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

$= \frac{6.6 \times 10^{-34}}{\sqrt{2 \times (4 \times 1.66 \times 10^{-27}) \times (2 \times 1.6 \times 10^{-19}) \times V}}$

$= \frac{0.101}{\sqrt{V}}$

139 **(b)**

Photo current (i) is directly proportional to light intensity (I) falling on a photosensitive plate, $i.e., i \propto I$

140 **(c)**

$y = \frac{1}{2}at^2 = \frac{1}{2}\frac{eE}{m}\frac{x^2}{v^2}$ or $\frac{e}{m} = \frac{2\,y\,v^2}{Ex^2}$

$= \frac{2 \times 1.5 \times 10^{-3} \times (3 \times 10^7)^2}{1800 \times (0.1)^2}$

$= 1.5 \times 10^{11}\ Ckg^{-1}$

141 **(a)**

E=W+KE

KE=E-W

$= \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$

$= hc\left[\frac{1}{\lambda} - \frac{1}{\lambda_0}\right] = hc\left[\frac{\lambda_0 - \lambda}{\lambda\lambda_0}\right]$

142 **(c)**

KE of emitted electron is

$E_K = hv - W$

$= 6.2\ eV - 4.2\ eV = 2.0\ eV$

$= 2 \times 1.6 \times 10^{-19}\ J$

$= 3.2 \times 10^{-19} J$

143 **(a)**

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

$= \frac{6.62\times10^{-34}\times3\times10^{8}}{45\times10^{-12}}$

$= \frac{0.44\times10^{-14}}{1.6\times10^{-19}} = 0.275 \times 10^5\ \text{eV} = 27500\ \text{eV}$

144 **(b)**

The photoelectric effect is an instantaneous phenomenon (experimentally proved). It takes approx time of the order of 10^{-10}s.

145 **(b)**

Stoke's law

146 **(b)**

Here the velocity of electron increases, so as per Einstein's equation mass of the electron increases, hence the specific charge $\frac{e}{m}$ decreases

147 **(a)**

Less than 40 keV

148 **(a)**

Bragg's law states that $2d\ sin\ \theta = n\lambda$ where $= 1, 2, 3 \ldots\ldots$ If $\lambda > 2d$, then $sin\ \theta$ will be greater than 1 for $n = 1$, which is not possible

149 **(d)**

$KE_{max} = 10eV$

$\phi = 2.75eV$

$E = \phi + KE_{max} = 12.75eV$

$=$ Energy difference between $n = 4$ and $n = 1$

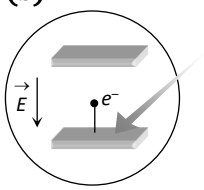
$\Rightarrow$ value of $n = 4$

150 **(c)**

$$\lambda = \frac{h}{p} \Rightarrow \lambda - \frac{0.5}{100}\lambda = \frac{h}{p + \Delta p} \Rightarrow \frac{199\lambda}{200} = \frac{h}{p + \Delta p} = \frac{199}{200}\frac{h}{p}$$

$$\Rightarrow p + \Delta p = \frac{200}{199}p \Rightarrow p = 199\ \Delta p$$

151 **(b)**



In electric field photoelectron will experience force and accelerate opposite to the field so it's $K.E.$ increases ($i.e.$, stopping potential will increase), no change in photoelectric current, and threshold wavelength

152 **(c)**

KE of photoelectron $= hv - W_0$

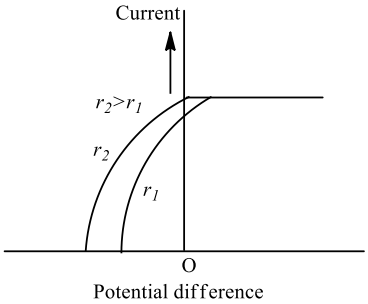
$$= \frac{hc}{\lambda} - W_0$$
$$= \frac{6.63\times10^{-34}\times3\times10^{8}}{300\times10^{-9}} - 2.54\times1.6\times10^{-19}$$
$$= 6.63\times10^{-19} - 4.064\times10^{-19}$$
$$= 2.566\times10^{-19}\ eV$$

If V_0 is the stopping potential, then KE of photoelectron $= eV_0$

or $$V_0 = \frac{KE\ of\ photo\ electron}{e}$$
$$= \frac{2.566\times10^{-19}}{1.6\times10^{-19}} = 1.60V$$

153 **(c)**

The negative potential at which photoelectric current becomes zero is called stopping potential. If at the stopping potential light of frequency higher than before be made to fall on plate, then photoelectric current is re-established. On increasing the negative potential of other plate, the current again stops. Hence, higher the frequency of the incident light,higher will be the maximum kinetic energy of the emitted photoelectrons or higher will be the stopping potential.



154 **(b)**

$$p = \frac{E}{c} = \frac{hv}{c} \Rightarrow v = \frac{pc}{h}$$

155 **(a)**

de-Broglie wavelength, $\lambda = \frac{h}{\sqrt{2mE_k}}$

$$\frac{\lambda_\alpha}{\lambda_p} = \sqrt{\frac{m_p}{m_\alpha}}$$
$$= \sqrt{\frac{1}{4}} = \frac{1}{2}$$

156 **(b)**

$$v = \frac{c}{\lambda} = \frac{3\times10^{8}}{1\times10^{-10}} = 3\times10^{18}Hz$$

157 **(a)**

The value of threshold frequency v_0 for A is less than that for B, hence $\phi_A < \phi_B$

158 **(a)**

Specific charge=charge/mass. The positive rays are stream of positive ions. The mass of positive ion is much more than that of electrons, hence specific charge of positive ions is less

159 **(c)**

When filament current is increased, more electrons are emitted from electron gun. Due to which the intensity of electrons increases.

As $\lambda_{min} = \frac{hc}{eV}$, so as V decreases, λ_{min} increases.

160 **(b)**

$$\frac{1}{2}mv^2 = eV \Rightarrow \frac{e}{m} = \frac{v^2}{2V} = \frac{(8.4\times10^{6})^2}{2\times200} = 1.76\times10^{11}\frac{C}{kg}$$

161 **(a)**

$\lambda_r > \lambda_y > \lambda_g$. Here threshold wavelength $< \lambda_y$

162 **(a)**

Here, $u = 0; a = \frac{eE}{m}; v = ?; t = t$

$$\therefore \quad v = u + at = 0 + \frac{eE}{m}t$$

de-Broglie wavelength,

$$\lambda = \frac{h}{mv} = \frac{h}{m(eEt/m)} = \frac{h}{eEt}$$

Rate of change of de-Broglie wavelength

$$\frac{d\lambda}{dt} = \frac{h}{eE}\left(-\frac{1}{t^2}\right) = \frac{-h}{eEt^2}$$

163 **(b)**

Given $E/c = 3.3 \times 10^{-13} kg\ ms^{-1}$;

So, $E = 3.3 \times 10^{-13} \times c = 3.3 \times 10^{-13} \times 3 \times 10^8$

$= 9.9 \times 10^{-5}$ J

164 **(a)**

Characteristic X-ray

165 **(d)**

$$QE = mg \Rightarrow mg = \frac{QV}{d}$$

664 **(a)**

$$E_e = \frac{1}{2}mv^2 = \frac{1}{2}(mv)v = \frac{1}{2}\left(\frac{h}{\lambda}\right)v$$

and $E_p = \frac{hc}{\lambda}$;

$$\therefore \frac{E_e}{E_p} = \frac{v}{2c}$$

$p_e = mv = h/\lambda$ and $p_h = \frac{h}{\lambda}$

$$\therefore \frac{p_e}{p_h} = 1$$

166 **(a)**

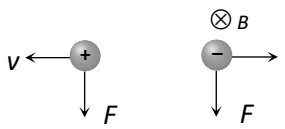
$$\frac{E_e}{E_p} = \frac{v}{2c}$$

167 **(d)**

When current through the filament increases, number of emitted electrons also increases. Hence intensity of X-ray increases but no effect on penetration power

168 **(a)**

In discharge tube cathode rays (a beam of nregative particles) and canal rays (positive rays) move opposite to each other. They will experience a magnetic force in the same direction, if a normal magnetic field is applied



Assertion - Reasoning Type

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

a) Statement 1 is True, Statement 2 is True; Statement 2 **is** correct explanation for Statement 1
b) Statement 1 is True, Statement 2 is True; Statement 2 **is not** correct explanation for Statement 1
c) Statement 1 is True, Statement 2 is False
d) Statement 1 is False, Statement 2 is True

1 **Statement 1:** The de-Broglie wavelength of a molecule varies inversely as the square root of temperature.
Statement 2: The root mean square velocity of the molecule depends on the temperature.

2 **Statement 1:** Work function of copper is greater than the work function of sodium, but both have same value of threshold frequency and threshold wavelength.
Statement 2: The frequency is inversely proportional to wavelength.

3 **Statement 1:** If the accelerating potential in an X-ray tube is increased, the wavelengths of the characteristic X-rays do not change.
Statement 2: When an electron beam strikes the target in an X-ray tube, part of the kinetic energy is converted into X-ray energy.

4 **Statement 1:** Photoelectric effect can take place only with an electron bound in the atom.
Statement 2: Electron is a fermion whereas proton is a boson.

5 **Statement 1:** In the process of photoelectric emission, all the emitted photoelectrons have the same kinetic energy
Statement 2: The photon transfer its whole energy to the electron of the atom in photoelectric effect

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

7 **Statement 1:** Standard optical diffraction can not be used for discriminating between different X ray wavelengths
Statement 2: The grating spacing is not of the order of X-ray wavelengths

8 **Statement 1:** Photosensitivity of a metal is high if its work function is small.
Statement 2: Work function $=hf_0$ where f_0 is the threshold frequency.

9 **Statement 1:** A tube light emits white light.
Statement 2: Emission of light in a tube takes place on a very high temperature.

10 **Statement 1:** Davisson-Germer experiment established the wave nature of electrons
Statement 2: If electrons have wave nature, they can interfere and show diffraction

11 **Statement 1:** When ultraviolet light is incident on a photocell, its stopping potential is V_0 and the maximum kinetic energy of the photoelectrons is Kmax . When the ultraviolet light is replaced by X-rays, both V_0 and $K_{\max}$ increase.
Statement 2: Photoelectrons are emitted with speeds ranging from zero to a maximum value because of the range of frequencies present in the incident light.

12 **Statement 1:** In Millikan's experiment for the determination of charge on an electron, oil drops of any size can be used
Statement 2: Millikan's experiment determines the charge on electron, by simply measuring the terminal velocity

13 **Statement 1:** In photoemissive cell inert gas is used
Statement 2: Inert gas in the photoemissive cell gives greater current

14 **Statement 1:** X-rays are used for studying the structure of crystals
Statement 2: The distance between the atoms of crystals is of the order of wavelength of X-rays

15 **Statement 1:** The photoelectrons produced by a monochromatic light beam incident on a metal surface have a spread in their kinetic energies
Statement 2: The work function of the metal varies as a function of depth from the surface

16 **Statement 1:** X-rays travel with the speed of light
Statement 2: X-rays are electromagnetic rays

17 **Statement 1:** Electric conduction in gases is possible at normal pressure
Statement 2: The electric conduction in gases depends only upon the potential difference between the electrodes

18 **Statement 1:** The phenomenon of X-ray production is basically inverse of photoelectric effect
Statement 2: X-rays are electromagnetic waves

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

20 **Statement 1:** The energy (E) and momentum (p) of a photon are related by $p = E/c$
Statement 2: The photon behaves like a particle

21 **Statement 1:** In photoelectric effect, on increasing the intensity of light, both the number of electrons emitted and kinetic energy of each of them get increased but photoelectric current remains unchanged
Statement 2: The photoelectric current depends only on wavelength of light

22 **Statement 1:** A metallic surface is irradiated by a monochromatic light of frequency $v > v_0$ (the threshold frequency). The maximum kinetic energy and the stopping potential are $K_{\max}$ and V_0 respectively. If the frequency incident on the surface is doubled, both the $K_{\max}$ and V_0 are also doubled
Statement 2: The maximum kinetic energy and the stopping potential of photoelectrons emitted from a surface are linearly dependent on the frequency of incident light

: ANSWER KEY :

1)	b	2)	d	3)	b	4)	c	5)	d	6)	c	7)	a	8)	b
9)	c	10)	a	11)	c	12)	d	13)	a	14)	a	15)	c	16)	a
17)	d	18)	b	19)	a	20)	a	21)	d	22)	d				

: HINTS AND SOLUTIONS :

1 **(b)**

de-Broglie wavelength associated with gas molecules varies as

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

Also root mean square velocity of gas molecules is

$$v_{\text{rms}} = \sqrt{\frac{3RT}{M}}$$

2 **(d)**

When work function of copper is greater than the work function of sodium, then

$\phi_{\text{Cu}} > \phi_{\text{Na}}$

$(hv_0)_{\text{Cu}} > (hv_0)_{\text{Na}}$ ...(i)

But we know that $v_0 = \frac{c}{\lambda_0}$

Hence Eq.(i) becomes

$$\left(\frac{hc}{\lambda_0}\right)_{\text{cu}} > \left(\frac{hc}{\lambda_0}\right)_{\text{Na}}$$

$(\lambda_0)_{\text{Na}} > (\lambda_0)_{\text{Cu}}$

3 **(b)**

Cut-off wavelength depends on the accelerating voltage, not the characteristic X-rays. Further approximately 2% kinetic energy of the electrons is utilised in producing X-rays. Rest 98% is lost in heat.

4 **(c)**

The photoelectric effect is the emission of electrons (called photoelectrons) when light strikes a metal surface. Hence photoelectric effect can take place only with an electron bound in the atom. Electron is a lepton whereas proton is fermion.

5 **(d)**

Only the photoelectrons emitted from the surface of the metal have maximum kinetic energy. Those emitted from inside the metal loses part of their energy in collision with the other atoms inside the metal

6 **(c)**

Photoelectric effect is based upon quantum theory of light or particle nature of light.

The number of photoelectrons emitted is proportional to intensity of incident light. It does not depend on frequency of light.

7 **(a)**

8 **(b)**

Work function is the minium energy required to eject the photoelectron from photosensitive metal. Hence, for metal to be photosensitive, the work function should be small work function=$hf_{0'}$ where fo is threshold frequency.

9 **(c)**

A tube light is a gas discharge tube which can emit light of different colours. This colour mainly depends upon the nature of the gas inside the tube and the nature of the glass. The light emitted is due to fluorescence emission of light when argon is filled in tube. It takes place at low pressure but not at high temperature.

10 **(a)**

11 **(c)**

Since the frequency of ultraviolet light is less than the frequency of X-rays, the energy of each incident photon will be more for X-rays

$KE_{photoelectron} = hv - \phi$

Stopping potential is to stop the fastest photoelectron

$V_0 = \frac{hv}{e} - \frac{\phi}{e}$

So, KE_{max} and V_0 both increases.

But KE ranges from zero to KE_{max} because of loss of energy due to subsequent collisions before getting ejected and not due to range of frequencies in the incident light.

12 **(d)**

In Milkan's experiment oil drops should be of microscope sizes. If much bigger oil drops are used, then a very high electric field will be required to balance it which is not possible to achieve practically

Further, the apparent weight of the liquid $\frac{4}{3}\pi a^3 g\left(\rho_{\text{liquid}} - \sigma_{\text{air}}\right) = 6\pi a\, \eta v$

If a is large, v will be large and the experimental errors will be high

13 **(a)**

The photoemissive cell may be evacuated contain an inert gas at low pressure. An inert gas in the cell gives greater current but causes a time lag in the response of the cell to very rapid changes of radiation which may make it unsuitable for some purpose

14 **(a)**

The distance between the atoms of crystals is of the order of wavelength of X-rays. When they fall on a crystal, they are diffracted. The diffraction pattern is helpful in the study of crystal structure

15 **(c)**

$KE_{\max} = hv = \phi$

$0 \le KE_{Photoelectrons} \le KE_{\max}$, Also ϕ of material is constant

16 **(a)**

X-rays lie in electromagnetic spectrum

17 **(d)**

At normal pressure positive ions and electrons liberated by ionisation of gas atoms, due to cosmic rays are very small in number and they collide constantly with the gas atoms which are present in large numbers, and hence are unable to move a long distance under the electric field and soon get recombined $i.e.$, flow of ions in the gas does not take place

18 **(b)**

In photoelectric effect, the photon falling on some matter is absorbed by the matter and its energy is transferred to an electron of the matter. In X-ray production, photons are produced which get energy from energetic electrons ionizing the inner shells of the target which in turn cause a cascade of emission lines

19 **(a)**

Equivalent mass of photon (m) is given by

$$E = mc^2 = hv \Rightarrow m = \frac{hv}{c^2}$$

Therefore, momentum of photon

$$= mc = \frac{hv}{c^2} \times c = \frac{hv}{c}$$

Thus, photon possessed momentum due to its equivalent mass even its rest mass is zero.

20 **(a)**

Momentum of a photon is given by $p = \frac{h}{\lambda}$

Also the photon is a form of energy packets behaves as a particle having energy $E = \frac{hc}{\lambda}$. So $p = \frac{E}{c}$

21 **(d)**

On increasing the intensity of incident light, the current in photoelectric cell will increase. The energy of the photons (hv) will, however not increase with increase in intensity, and hence the kinetic energy of the emitted electrons will not increase

22 **(d)**

$hv = hv_0 + k_{\max} \Rightarrow k_{\max} = hv - hv_0$

Matrix Match Type

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

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

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

CODES :

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

: ANSWER KEY :

1)	**a**														

: HINTS AND SOLUTIONS :

1 **(a)**

Column I		Column II	
(A)	Transition between two atomic energy levels	1.	Hydrogen spectrum
(B)	Electron emission from a material	2.	β-decay
(C)	Moseley's law	3.	Characteristic X-rays
(D)	Change of photon energy into kinetic energy of electrons	4.	Photoelectric effect