Chapter

11

DUAL NATURE OF RADIATION AND MATTER

1. Gases are non- conductor at NTP. They are most conducting at
   (a) Low temperature and low pressure
   (b) Low temperature and high pressure
   (c) High temperature and low pressure
   (d) High temperature and high pressure

2. When electric field is applied between cathode and anode at pressure of about 0.001 mm of mercury in a discharge tube , following is observed.
   (a) There is discharge in the tube
   (b) A zig-zag thin spark runs from cathode to anode
   (c) Whole of tube is filled with bright light
   (d) A fluorescent glow appeared

3. Colour of glow in a discharge tube at a pressure of 0.001 mm of mercury column depends on

   (a) Nature of gas in the discharge tube
   (b) Potential diference between cathode and anode
   (c) Nature of material of cathode
   (d) Nature of glass of the discharge tube

4. Glow in discharge tube is due to
   (a) X-ray (b) positive rays
   (c) cathode rays (d) collision of gas ions

5. Cathode ray are
   (a) stream of positive ions
   (b) streams of negatively charged particles
   (c) streams of nuclei
   (d) stream of neutrons

6. Cathode rays are streams of fast moving negatively charged particles. Their speed range is (consider c ≈ $3 \times 10^8 ms^{-1}$)
   (a) 0.1 c to 0.2 c
   (b) C
   (c) Greater than c
   (d) Around $10^{-5}c$ $10^{-3}c$

7. Specific charge of electrons is

   (a) $1.76 \times 10^{11} Ckg^{-1}$ (b) $1.6 \times 10^{-19} Ckg^{-1}$
   (c) $9.11 \times 10^{-31} Ckg^{-1}$ (d) $1.67 \times 10^{-27} Ckg^{-1}$

8. RA millikan during his oil - drop experiment on electron found that the charge on an oil drop is
   (a) A fraction of $1.6 \times 10^{-19}C$
   (b) An even multiple of $1.6 \times 10^{-19}C$
   (c) An odd multiple of $1.6 \times 10^{-19}C$
   (d) An odd multiple of $1.6 \times 10^{-19}C$

9. X-ray can be deflected by applying

   (a) A magnetic field (b) an electric field
   (c) Both (a) and (b) (d) None of these

10. Gases begin to conduct electricity at low pressure because

    (a) At low pressure gases turn to plasma

    (b) Colliding electrons can acquire higher kinetic energy due to increased mean path leading to ionization of atoms

    (c) Atom break into ions and electrons

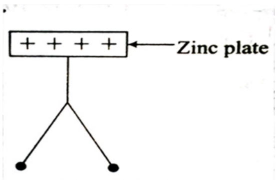
    (d) The electrons in atoms can move freely at low pressure

11. Cathode rays are produced when the pressure is of order of
   (a) 2cm of Hg (b) 0.1 cm of Hg
   (c) 0.001 mm of Hg (d) 10 cm of Hg
12. In Millikan's oil drop experiment an oil drop having charge q gets stationary on applying a potential difference V 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) $q\frac{V}{d}$

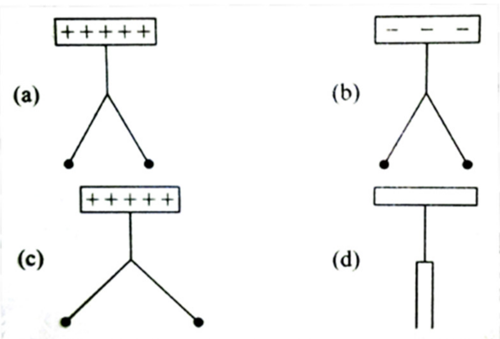
13. Work - function is least for

   (a) caesium (b) aluminium
   (c) silver (d) platinum

14. A positively charged zinc plate is connected to an electroscope .



It is then irradiated by UV – light. Result is



15. Photoemission with visible light is possible in
   (a) alkali metals (b) alkaline earth metals
   (c) metalloids (d) semiconductors

16. When ultraviolet rays are incident on a metal surface the photoelectric effect does not occur. It may occur by the incidence of
   (a) X- rays (b) radio wave
   (c) Infrared rays (d) sound waves

17. Light used to emit electrons from metal plate is
   (a) short wavelength (b) long wavelength
   (c) polarized light (d) low speed

18. While studying , effect of variation of intensity on the photocurrent , intensity of light is changed in a photocell by
   (a) Using a prism in the path of light beam
   (b) Using a thick glass sheet
   (c) Tilting the cathode
   (d) Changing the distance of light source from the emitter

19. Number of photoelectrons emitted per second is proportional to the
   (a) Intensity of incident radiation
   (b) Colour of incident radiation
   (c) Angle of incidence of incident radiation
   (d) Potential difference of collector and emitter plates

20. An electron gun with its anode at a potential difference of 120 V fires out electron in a spherical bulb containing hydrogen gas at low pressure (10^{-2}mm of Hg). A magnetic field of $2.5 \times 10^{-4}T$ curves the path of the electron in a circular orbit of radius 13 cm . The e/m ratio is
   (a) $2.27 \times 10^{-11}Ckg^{-1}$
   (b) $2.27 \times 10^{8}Ckg^{-1}$
   (c) $2.27 \times 10^{-8}Ckg^{-1}$
   (d) $2.27 \times 10^{11}Ckg^{-1}$

21. In an experiment on photoelectric effect , the slope of the cut– off voltage versus frequency of incident light is found to be $12 \times 10^{-15}V - s$. Calculate the value of Planck's constant.

   (a) $6.0 \times 10^{-34}Js$ (b) $0.63 \times 10^{-34}Js$
   (c) $6.59 \times 10^{-34}Js$ (d) 0

22. A beam of wavelength λ and intensity I falls over a clean surface of sodium metal . If N photoelectrons are emitted with kinetic energy E , then
   (a) $N \propto I$ and $E \propto I$ (b) $N \propto I$ and $E \propto \frac{1}{\lambda}$
   (c) $N \propto \lambda$ and $E \propto I$ (d) $N \propto \frac{1}{\lambda}$ and $E \propto \frac{1}{I}$

23. The cathode of a photoelectric cell is changed such that the work function changes from W_1 to W_2 $(W_2 > W_1)$. If the current before and after change are I_1 and I_2 , all other conditions remaining unchanged and assuming $(E_1 > W_2)$, then

(a) $I_1 = I_2$ (b) $I_1 < I_2$
(c) $I_1 > I_2$ (d) $\frac{W_1}{W_2} = \frac{I_1}{I_2}$

24. According to wave theory , time required for photoemission is

(a) less than 10 s (b) around $10^{-9}s$
(c) around 1s (d) around few hours

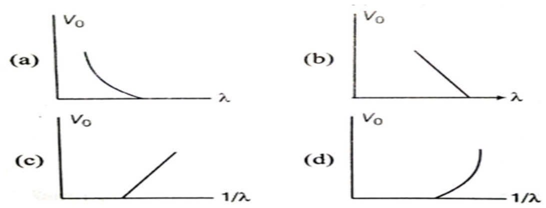
25. Light of intensity $10^{-5}Wm^{-2}$ falls on sodium photo cell of surface area 2 cm^2 and work function 2eV. Assuming that, Only top 5 layears of sodium absorbs the incident energy and effective atomic area of sodium atom is $10^{-20}m^{-2}$, the time required for photomission in wave picture of light is nearly

(a) $10\frac{1}{2}s$ (b) $\frac{1}{2}s$ (c) $\frac{1}{2}h$ (d) $\frac{1}{2}yr$

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

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

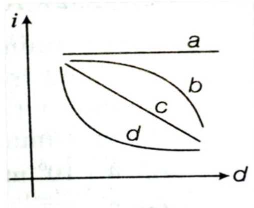
27. For photoelectric effect with incident photon wavelength λ , the stopping potential is V . Identify the correct variation of V_0 with λ_0 and $\frac{1}{\lambda}$.



28. V_0 versus v curve is a

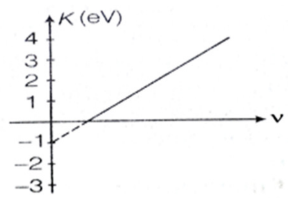
(a) Straight line with slope = ϕ_0
(b) Straight line with slope = ϕ_0/e
(c) Straight line with slope = h/e
(d) Straight line with zero slope

29. A point source of light is used in an experiment on photoelectric effect . Which of the following curves best represents the variation of photoelectric current i with distance d of the source from the emitter ?



(a) a (b) b (c) c (d) d

30. Figure represents a graph of kinetic energy K of photoelectrons and frequency v for a metal used or cathode in photoelectric experiment . The work function of metal is



(a) 1 eV (b) 1.5 eV (c) 2eV (d) 3eV

31. When a metallic surface is illuminated with radiation of wavelength λ , the stopping potential is V . If the same surface is illuminated with radiation of wavelength 2λ , the stopping potential is $\frac{V}{4}$. The threshold wavelength for the metallic surface is

(a) 5 λ (b) $\frac{5}{2}\lambda$ (c) 3 λ (d) 4 λ

32. A metallic surfaces is irradiated by a monochromatic light of frequency v_1 and stopping potential is found to be V_1 . If the light of frequency v_2 irradiates the surface . The stopping potential will be

(a) $V_1 + \frac{h}{e}(v_1 + v_2)$ (b) $V_1 + \frac{h}{e}(v_1 - v_2)$
(c) $V_1 + \frac{e}{h}(v_2 + v_1)$ (d) $V_1 + \frac{h}{e}(v_1 + v_2)$

33. In experimenting with rubidium photocell, the following lines from a mercury source were used λ_1 3650 Å , λ_2 = 4047 Å , λ_3 = 4358 Å , λ_4 = 5461 Å , λ_5 = 6907 Å and stopping potentials respectively are V_{01} = 1.28 V , V_{02} = 0.95 V, V_{03} = 0.74 V, V_{04} = 0.16 V , V_{05} = 0V.

Threshold frequency and work -m function of metal are

(a) $4 \times 10^{14} Hz, 1.5\, eV$
(b) $4.3 \times 10^{14} Hz, 1.8\, eV$
(c) $4 \times 10^{14} Hz, 3\, eV$
(d) $1.5 \times 10^{14} Hz, 5\, eV$

34. A photoelectric surface is illuminated successively by monochromatic light of wavelength λ and $\lambda/2$.

If the maximum kinetic energy of the emitted photo electrons in the second case is 3 times than in the first case , the maximum kinetic energy of the emitted photoelectron in the second case is 3 times than in the first case , the work function of the surface of the material is
(h = Plank's constant , c = speed of light)

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

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

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

36. Millikan proved validity of Einstein's photoelectric equation by

(a) Finding work - function (ϕ_0)
(b) Finding planck's constant (h)
(c) Finding change of electron (e)
(d) Finding mass of electron (m)

37. Einstein's picture of photoelectric effect was accepted using

(a) The hypothesis of light quanta's
(b) The experimental determination of values of h and ϕ_0
(c) Both (a) and (b)
(d) Neither (a) nor (b)

38. An electric eye is

(a) An LED (b) a photocell
(c) a solar cell (d) a photo diode

39. Monochromatic light of frequency $6.0 \times 10^{14} Hz$ is produced by a laser. The energy of a photon in the light beam is

(a) $5 \times 10^{-15} J$ (b) $3.98 \times 10^{-19} J$
(c) $2.54 \times 10^{-14} J$ (d) $5.16 \times 10^{-14} J$

40. A laser beam of frequency $6.0 \times 10^{14} Hz$ is emitted from a source of $2\times 10^{-3} W$. Number of photons emitted per second is

(a) 5×10^{-19} (b) 5.16×10^{14}
(c) 3.98×10^{19} (d) 5×10^{15}

41. The linear momentum of a 6 MeV photons is

(a) 0.01 $eV\, sm^{-1}$ (b) 0.02 $eV\, sm^{-1}$
(c) 0.03 $eV\, sm^{-1}$ (d) 0.0 4 $eV\, sm^{-1}$

42. If an electron is accelerated from rest through [potential of $V -$ volts, then kinetic energy K gained by it

(a) $K = eV$ (b) $K = \frac{1}{2} eV$
(c) $K = \frac{2}{3} eV$ (d) $K = 0$

43. 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 the electron at time t ignoring relativistic effect is

(a) $\frac{-h}{eEt^2}$ (b) $\frac{eE\,t}{E}$ (c) $\frac{-mh}{eEt^2}$ (d) $\frac{-h}{eE}$

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

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

45. A proton and an $\propto$ - particle are acceleration through the same potential difference . The ratio of de-Broglie wavelength λ_P to that of $\lambda_\propto$ is

(a) $\sqrt{2}$: 1 (b) $\sqrt{4}$: 1 (c) $\sqrt{6}$:1 (d) $\sqrt{8}$: 1

46. There are two source of light , each emitting with a power of 200 W . One emits X-rays of wavelength 2nm and the other visible of 400nm . The ratio of number of photons of X-rays to the photons of visible light of the given wavelength is

(a) 1 : 100 (b) 1 : 200 (c) 1 : 500 (d) 1 : 300

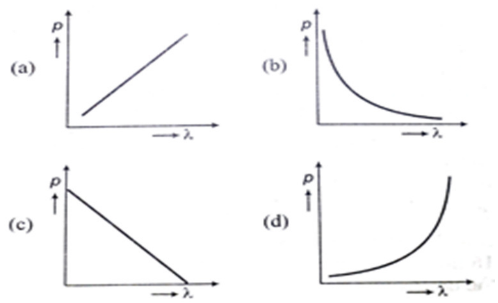
47. If the kinetic energy of the particle is increased to 16 times its previous value , the percentage change in the de- Broglie wavelength of the particle is

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

48. The work function for aluminium surface is 4.2 eV. The cut - off wavelength for the photoelectric effect is

(a) 2955 Å (b) 4200 Å (c) 2000 Å (d) 1000 Å

49. Which of the following figure represent the variation of particle momentum and the associated de- Broglie wavelength ?



50. What is the basic idea behind experimental verification of de-Broglie hypothesis ?

(a) Wavelength associated with electrons is of same order as spacing of atomic planes in crystal
(b) Wavelength associated with electrons is much larger than spacing of atomic planes in crystal
(c) Wavelength associated with electrons is much smaller than spacing of atomic planes in crystal
(d) It was taken from diffraction of X-rays from crystal planes

51. An electron is confined to a 1nm wide region . Find the uncertainty in momentum using Heisenberg uncertainty principle . $(h = 6.63 \times 10^{-34} J - s)$

(a) $1.05 \times 10^{-25} kgms^{-1}$
(b) $2.03 \times 10^{-31} kgms^{-1}$
(c) $3.05 \times 10^{-34} kgms^{-1}$
(d) $2.9 \times 10^{-32} kgms^{-1}$

52. Davisson— Germer experiment confirms de-Broglie relation by

(a) Converting electrons into waves
(b) Converting light into particles
(c) Varying angle of incidence of an electron beam over a metal target and observing scattering pattern
(d) Comparing theoretical value of wavelength associated with moving electrons and particle value of wavelength measured by observing diffraction pattern produced by electrons

53. In Division –Germer experiment, the wavelength associated with nickel crystal

(a) 1.66 Å (b) 2 Å (c) 2.3 Å (d) 3.86 Å

Hints and Explanations

1. (c)
At low pressure and high temperature , free electrons are generated and positively charged atom (or molecule) which is called an ion is created . hence , conduction is possible .

2. (d)
It was found that at sufficiently low pressure of about 0.001 mm of mercury column , a discharge tube place between the two electrodes an applying the electric field to the gas.
A fluorescent glow appeared opposite to cathode.

3. (d)
In the discharge tube a fluorescent glow is seen on the glass opposite to cathode . The colour of glow of the glass depended on the type of glass , it being yellowish - green for soda glass

4. (c)
Glow is due to the radiation which appeared to be coming from the cathode.
5. (b)
Cathode rays are streams of negatively charged particles.

6. (a)
The particles speed ranges from 0.1c to 0.2c. Here , c is the speed of light in vacuum which is $3 \times 10^8 ms^{-1}$.

7. (a)
Specific charge is 1.76$\times 10^{11} C\ kg^{-1}$. By applying mutually perpendicular electric and magnetic fields across the discharge tube , JJ Thomson was the first to determine the speed and the specific charge [Charge to mass ratio (e/m)] of the cathode ray particles.

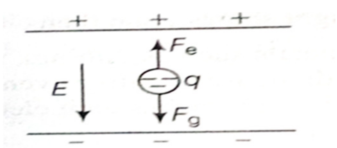
8. (d)
It is found the charge on an oil - droplet was always an integral multiple of an elementary charge , 1.6 $\times 10^{-19} C$. Millikan's experiment established that electric charge is quantized . From the values of charge € and specific charge (e/m) the mass (m) of the elctron could be determined .

9. (d)
X-rays does not have charge particle they are simple electromagnetic radiation , hence , it cannot be deflected by applying electric and magnetic fields

10. (c)
Atom break into proton and electron at low pressure.

11. (c)
Pressure is of the order of $10^{-2} mm$ of Hg.

12. (d)
As the drop is stationary , then we say that



$\Rightarrow \quad F_e = F_g$

$qE = F_g$ (F_g = weight)

$\Rightarrow$ weight $= qE = q\frac{V}{d}$

13. (a)
The work function of platinum is the highest (ϕ= 5.65 eV) while it is the lowest (ϕ_0= 2.14 eV) for caesium .

14. (c)
Positive charge on a positively charged zinc plate was found to be further enhanced when it was it was illuminated by ultraviolet light . So , leaves of electroscope will move further apart.

15. (a)
Some alkali metals such as. lithium , sodium , potassium , caesium and rubidium are sensitive even to visible light . All these photosensitive substances emit electrons when they are illuminated by light.

16. (a)
Frequency of X- rays is much higher than ultraviolet - light . so photoemission might be possible with X-rays . For photoemission , a minimum frequency called threshold frequency is required . Below threshold frequency photoemission does not occurs.

17. (a)
Short wavelength light have high frequency and photoemission occurs .

$C = v\lambda$ or $v = \frac{c}{\lambda}$

For constant wave velocity (as in case of electromagnetic radiation in vacuum , C = $3 \times 10^8 ms^{-1}$), the frequency is inversely proportional to wavelength . high frequency light carries more energy [$E = hv$] and hence photoemission easily occurs.

18. (d)
Intensity of light reaching a surface is inversely proportional to square of its distance from source.

Intensity $\propto \frac{1}{(Distance\ )^2}$

19. (a)
As photocurrent increases with increase in intensity , so we can say that number of photoelectrons emitted per second is proportional to intensity of radiation .

20. (d)

B = 2.5 $\times 10^{-4} T$
V = 120 V
$r = 13cm$ =13 $\times 10^{-2} m$

When electrons are accelerated through V volts. The change in kinetic energy of the electron is

$$\frac{1}{2}mv^2 = eV \quad \Rightarrow \quad v^2 = \frac{2\,eV}{m} \qquad \text{----- (i)}$$

As $evB = \frac{mv^2}{r}$ or $v = \frac{eB\,r}{m}$

$$\Rightarrow \quad v^2 = \frac{e^2B^2r^2}{m^2} \qquad \text{--------- (ii)}$$

(i) and (ii)

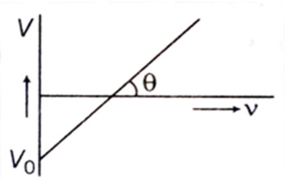
$$\frac{2\,eV}{m} = \frac{e^2B^2r^2}{m^2}$$

$$or \quad \frac{e}{m} = \frac{2V}{r^2B^2} = \frac{2 \times 120}{(13 \times 10^{-2})^2 \times (2.5 \times 10^{-4})^2}$$

$$= 2.27 \times 10^{11} Ckg^{-1}$$

21. (c)

Slope of graph , tan θ = 4.12 × $10^{-15} V$-s and charge on electron e = 1.6 × $10^{-19} C$



tan $\theta = \frac{\Delta V}{\Delta v}$

$eV = hv - \phi$

$\Rightarrow \frac{\Delta V}{\Delta v} = \frac{h}{e}$

$\therefore \frac{h}{e}$ = 4.12 × 10^{-15}

h = 1.6 × 10^{-19} × 4.12 × 10^{-15}

= 6.592 × $10^{-34} J - s$

22. (b)

$N \propto I$

$f.\lambda$ = speed of light (f is frequency)

$\therefore \quad f \propto \frac{1}{\lambda}$

$E \propto f \Rightarrow \propto \frac{1}{\lambda}$

23. (a)

Photocurrent depends only intensity of light . As in given problem , only work function is changed , so current values are same .

24. (d)

In the wave picture , the absorption of energy by electron take place continuously over entire wave front of the radiation . Since a large number of electrons absorb energy the energy absorbed per electrons unit time turns out to be small. Explicit calculations estimate that it can take hours or more for a single electron to pick up sufficient energy overcome the work function and come out of the metal .

25. (d)

Incident power of light = Intensity × Area

$P = IA = 10^{-5} \times 2 \times 10^{-4} = 2 \times 10^{-9} W$

Number of layers absorbing light is 5 , each sodium atom with effective atomic area of $10^{-20} m^2$.

Number of electrons absorbing energy

$$n' = n \times \frac{A}{A_e} = 5 \times \frac{2 \times 10^{-4}}{10^{-20}} = 10^{17}$$

A_e = effective area of sodium atom Energy absorbed per second by each electron

$$E = P/n' = 2 \times 10^{-9} / 10^{17} = 2 \times 10^{-26} js^{-1}$$

$\therefore$ Time required for photoemission in wave picture of light

$$\phi_0 / E = \frac{2 \times 1.6 \times 10^{-19} J}{2 \times 10^{-26} js^{-1}} = 1.6 \times 10^7 s = 0.507\, yr$$

$$= \frac{1}{2} yr$$

26. (b)

The maximum kinetic energy of the emitted electron given by

$$K_{max} = hv - \phi_0 = h(6v) - h(v) = 5\,hv$$

27. (a,c)

$$eV_0 = \frac{hc}{\lambda} - W$$

$$V_0 = \left(\frac{hc}{e}\right)\left(\frac{1}{\lambda}\right) - \frac{W}{e}$$

V_0 versus λ graph is in the from $y = mx - c$

V_0 versus $\frac{1}{\lambda}$ graph is not a straight line but V_0 decreases with increase in λ and V_0 becomes zero when $\frac{hc}{\lambda} = W$.

$i.e.,$ $\lambda = \lambda_0$ (Threshold wavelength)
$\therefore$ option (a) is also correct .

28. (c)
The photoelectric equation can be written as
$eV_0 = h\nu - \phi_0$, for $\nu \geq \nu_0$
$or \quad \nu_0 = \frac{h}{e}\nu - \frac{\phi_0}{e}$

This is an important result , It predicts that the V_0versus v curve is a straight line with slope = (h/e) , independ of the nature of the material .

29. (d)
As the distance of source from the surface increases , intensity of radiation decreases .
Intensity = $\frac{1}{(distance)^2}$ and photocurrent ∝ Intensity

30. (a)
$K_{max} = h\nu - \phi_0$
(Einstein's photoelectric equation)
Above equation is equation of a straight line with y-intercept ϕ_0 , so from graph , work function is 1 eV .

31. (c)
In Ist case , when a metallic surface is illuminated with radiation of wavelength λ , the stopping potential is V. So, photoelectric equation can be written as

$eV = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$ ------ (i)

in $II\,nd$ case , when the same surface is illuminated with radiation of wavelength 2 λ , the stoping potential is $\frac{V}{4}$.

$\frac{eV}{4} = \frac{hc}{2\lambda} - \frac{hc}{\lambda_0} \implies eV = \frac{4\,hc}{2\,\lambda} - \frac{4\,hc}{\lambda_0}$ ----- (ii)
$(i)\ and\ (ii)$
$\implies \frac{hc}{\lambda} - \frac{hc}{\lambda_0} = \frac{4\,hc}{2\,\lambda} - \frac{4\,hc}{\lambda_0}$
$\implies \frac{1}{\lambda} - \frac{1}{\lambda_0} = \frac{2}{\lambda} - \frac{4}{\lambda_0} \implies \lambda_0 = 3\,\lambda$

32. (b)
Maximum kinetic energy ,
$K_{max} = \frac{1}{2}mv^2 = eV_0$
V_0 is the stopping potent electric equation
$h\nu_1 = \phi_0 + eV_1$
$h\nu_2 = \phi_0 + eV_2$
$\therefore \quad h = (\nu_1 - \nu_2) = e(v_1 - v_2)$
$\frac{h}{e}(\nu_1 - \nu_2) = v_1 - v_2$
Or $v_2 = v_1 + \frac{h}{e}(\nu_1 - \nu_2)$

33. (b)
Frequency of lines can be found by using $\nu = \frac{c}{\lambda}$ and they are listed in tabular form as

$f \times 10^{14} Hz$	8.219	7.412	6.884	5.493	4.343
V_0	1.28	0.95	0.74	0.16	0

From the table , frequency $f_0 = 4.343 \times 10^{14} Hz$
Work function = $\phi_0 = h\nu f_0 \approx$ 1.8eV

34. (a)
According to Einstein photoelectric equation
$E = K_{max} + \phi$
K_{max} is maximum kinetic energy of emitted electron and ϕ is work function of an electron
$K_{max} = E - \phi = h\nu - \phi$

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

In second case , maximum kinetic energy of emitted electron is 3 times that in first case ,
$3K_{max} = \frac{hc}{\lambda/2} - \phi$

(i) And (ii) we get work function of an emitted electron from a metal surface

$\phi = \frac{hc}{2\,\lambda}$

35. (a)
According to Einstein 's photoelectric emission of light
$E = (kE)_{max} + \phi$ as $\frac{hc}{\lambda} = (kE)_{max} + \phi$

If the wavelength of radiation is changed to $\frac{3\,\lambda}{4}$, then
$\implies \frac{4}{3}\frac{hc}{\lambda} = \left(\frac{4}{3}(kE)_{max} + \frac{\phi}{3}\right) + \phi$

Fastest emitted electron , $(kE)_{max} = \frac{1}{2}mv'^2 + \phi$

$\Rightarrow \quad \frac{1}{2}mv'^2 = \frac{4}{3}\left(\frac{1}{2}\,mv^2\right) + \frac{\phi}{3}$

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

36. (b)
Millikan performed a series of experiments on photoelectric effect . He measured the slop of the straight line obtained for sodium .

Using the known value of e, he determined the value of plank's constant h . This value was close to the value of Plank's constant $(6.626 \times 10^{34} js)$ determined in an entirely different context .

37. (c)
The successful explanation of photoelectric effect using the hypothesis of light quanta and the experimental determination of values of h and ϕ_0 in agreement with values obtained from other experiments , led to the acceptance of Einstein's picture of photoelectric effect.

38. (b)
It is a photocell . As a photocell converts variation of intensity of light into variation of current , we can say it is sensitive to intensity of light like an eye.
It is based on the application of photoelectric effect.

39. (b)
Energy of photons = hv
$=(6.626 \times 10^{-34} js) \times (6 \times 10^{14} s^{-1})$
$= 3.98 \times 10^{-19} J$

40. (d)
Number of photons emitted per second
= Power of the source / Energy of one photon
$= \frac{2 \times 10^{-3}}{3.98 \times 10^{-19}} = 5 \times 10^{15}$ photons per second .

41. (b)
Energy of photon
$E = 6\,MeV = 6 \times 10^6 eV$

Linear momentum of the photon
$P = \frac{E}{c}$
$P = \frac{6 \times 10^6 eV}{3 \times 10^8 ms^{-1}} = 2 \times 10^{-2} eVsm^{-1}$

$= 0.02 eVsm^{-1}$

42. (a)
An electron (mass m , charge e) accelerated from rest through a potential V . The kinetic energy K of the electron equals to work done (eV) on it by the electric field
$\Rightarrow \quad K = eV$

43. (a)
u = 0 ; a = $\frac{eE}{m}$; v ? , t = t
$\therefore \quad v = U + at = 0 + \frac{eE}{m} t$ (from equation of motion)
de-Broglie wavelength ,
$\lambda = \frac{h}{mv} = \frac{h}{m\,(eEt\,/m)} = \frac{h}{eEt}$

Rate of change de-Broglie wavelength ,

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

44. (d)
Since , it is given that electron has mass m , de- Broglie's wavelength for an electron will be given as

$\lambda_e = \frac{h}{P}$ ----------- (i)

h = Plank's constant
P = Linear momentum of electron
As kinetic energy of electron , $E = \frac{P^2}{2m}$
$\Rightarrow \quad P = \sqrt{2\,mE}$ ------------- (ii)
(i) And (ii)

$\lambda_e = \frac{h}{\sqrt{2\,mE}}$ ----------- (iii)

Energy of photon can be given as

$E = hv$

$\Rightarrow E = \frac{hc}{\lambda_p} \Rightarrow \lambda_p = \frac{hc}{E}$ ------ (iv)

λ_p = de- Broglie's wavelength of photons .

$dividing\ Eq.\ (iii) by\ (iv)$

$\frac{\lambda_e}{\lambda_p} = \frac{hc}{\sqrt{2\,mE}} \cdot \frac{E}{hc} \quad \Longrightarrow \quad \frac{\lambda_e}{\lambda_p} = \frac{1}{c} \cdot \sqrt{\frac{E}{2m}}$

45. (d)

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

$\therefore \lambda \propto \frac{1}{\sqrt{mq}}$

$\therefore \frac{\lambda_p}{\lambda_\propto} = \frac{\sqrt{m_\propto q_\propto}}{\sqrt{m_p q_p}}$ $\quad (m_\propto = 4m_p \ , q_\propto = 2\,q_p)$

$\frac{\lambda_p}{\lambda_\propto} = \frac{\sqrt{4\,m_p \times 2e}}{\sqrt{m_p \times e}} = \sqrt{8} : 1$

46. (b)

$P =$ 200 W , λ_1 = 2nm , λ_2 = 400nm

n_1 and n_2 be the number of photons of X-rays and visible light emitted from the two sources.

$\therefore \quad n_1 \frac{hc}{\lambda_1} = n_2 \frac{hc}{\lambda_2}$ or $\frac{n_1}{\lambda_1} = \frac{n_2}{\lambda_2}$

$\Longrightarrow \frac{n_1}{n_2} = \frac{\lambda_1}{\lambda_2} = \frac{2}{400} = \frac{1}{200}$ = 1 :200

47. (b)

de-Broglie wavelength ,

$\lambda_1 = \frac{h}{P} = \frac{h}{\sqrt{2\,mK}}$ ------- (i)

$\lambda_2 = \frac{h}{\sqrt{2\,m \;\; 16\,K}} = \frac{h}{4\,\sqrt{2\,mK}} = \frac{\lambda_1}{4}$ ------ (ii)

λ_2 = 25 % of λ_1

There is 75% charge in the wavelength

48. (a)

If λ_0 is threshold wavelength , then work function

$\phi_0 = \frac{hc}{\lambda_0} \Longrightarrow \lambda_0 = \frac{hc}{\phi_0}$

$= \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{4.2 \times 1.6 \times 10^{-19}} \approx 2955$ Å

49. (b)

The de- Broglie wavelength is given by

$\lambda = h/P \quad \Longrightarrow$ P λ

This equation is in the form of yx = c , which is the equation of a rectangular hyperbola. Hence the graph given in option (b) is the correct one .

50. (a)

If an electron is accelerated through a potential difference of V volts, then wavelength associated with electron is

$\lambda = \frac{1.227}{\sqrt{V}}$ nm , where , V is the magnitude of acceleration potential in volts.

For a 120 V accelerating potential , above equation gives λ = 0.112 nm.

This wavelength is of the same order as the spacing between the atomic planes in crystals .

51. (a)

Δx = 1nm = $10^{-9} m$

By Heisenberg uncertainty principle

$\Delta x \, \Delta p = h$

$\therefore \Delta p = \frac{h}{\Delta x} = \frac{h}{2\,\pi\,\Delta x}$ $\quad (\therefore$ h = $6.63 \times 10^{-34})$

$= \frac{6.63 \times 10^{-34}}{2 \times \pi \times 10^{-9}} < 1.05 \times 10^{-25} kgms^{-1}$

52. (c)

53. (a)

For the nickel crystal , the interatomic separation is

d = 0.91 Å

According to Bragg's law , for first order diffraction maxima (n-1) ,

2d sin θ $\quad 1 \times \lambda$

λ = $2 \times 0.91 \times \sin 65^o$ = 1.65 Å