Dual Nature of Matter and Radiation

Question1

The threshold frequency of a metal with work function 6.63 eV is :
[27-Jan-2024 Shift 2]

Options:

A. 16×10^{15} Hz

B. 16×10^{12} Hz

C. 1.6×10^{12} Hz

D. 1.6×10^{15} Hz

Answer: D

Solution:

$$\phi_0 = h\nu_0$$

$$6.63 \times 1.6 \times 10^{-19} = 6.63 \times 10^{-34}\nu_0$$

$$\nu_0 = \frac{1.6 \times 10^{-19}}{10^{-34}}$$

$$\nu_0 = 1.6 \times 10^{15}\,\text{Hz}$$

Question2

Two sources of light emit with a power of 200W. The ratio of number of photons of visible light emitted by each source having wavelengths 300 nm and 500 nm respectively, will be :
[29-Jan-2024 Shift 2]

Options:

A. 1 : 5

B. 1 : 3

C. 5 : 3

D. 3 : 5

Answer: D

Solution:

$n_1 \times \frac{hc}{\lambda_1} = 200$

$n_2 \times \frac{hc}{\lambda_2} = 200$

$\frac{n_1}{n_2} = \frac{\lambda_1}{\lambda_2} = \frac{300}{500}$

$\frac{n_1}{n_2} = \frac{3}{5}$

Question3

The work function of a substance is 3.0 eV. The longest wavelength of light that can cause the emission of photoelectrons from this substance is approximately:
[30-Jan-2024 Shift 1]

Options:

A. 215 nm

B. 414 nm

C. 400 nm

D. 200 nm

Answer: B

Solution:

For P.E.E. : $\lambda \leq \frac{hc}{W_e}$

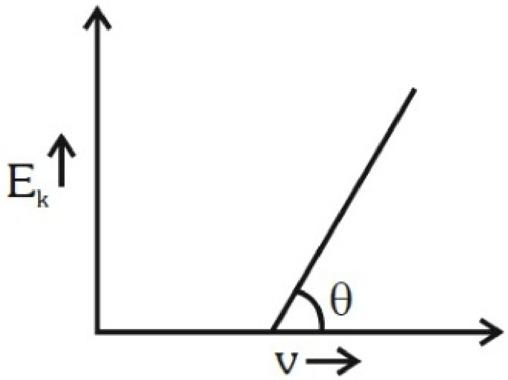
$\lambda \leq \frac{1240 \text{ nm} - \text{eV}}{3 \text{ eV}}$

$\lambda \leq 413.33 \text{ nm}$

$\lambda_{max} \approx 414 \text{ nm}$ for P.E.E.

Question4

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



[30-Jan-2024 Shift 2]

Options:

A. Ratio of Planck's constant to electric charge

B. Work function of the metal

C. Charge of electron

D. Planck's constant

Answer: D

Solution:

$$K.E. = hf - \phi$$

$$\tan\theta = h$$

Question5

When a metal surface is illuminated by light of wavelength λ, the stopping potential is 8V. When the same surface is illuminated by light of wavelength 3λ, stopping potential is 2V. The threshold wavelength for this surface is :
[31-Jan-2024 Shift 1]

Options:

A. 5λ

B. 3λ

C. 9λ

D. 4.5λ

Answer: C

Solution:

$E = \phi + K_{max}$

$\phi = \frac{hc}{\lambda_0}$

$K_{max} = eV_0$

$8e = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$..... (i)

$2e = \frac{hc}{3\lambda} - \frac{hc}{\lambda_0}$...... (ii)

on solving (i) & (ii)

$\lambda_0 = 9\lambda$

Question6

If the wavelength of the first member of Lyman series of hydrogen is λ. The wavelength of the second member will be
[31-Jan-2024 Shift 1]

Options:

A. $\frac{27}{32}\lambda$

B. $\frac{32}{27}\lambda$

C. $\frac{27}{5}\lambda$

D. $\frac{5}{27}\lambda$

Answer: A

Solution:

$\frac{1}{\lambda} = \frac{13.6z^2}{hc}\left[\frac{1}{1^2} - \frac{1}{2^2}\right]$...... (i)

$\frac{1}{\lambda'} = \frac{13.6z^2}{hc}\left[\frac{1}{1^2} - \frac{1}{3^2}\right]$......(ii)

On dividing (i) & (ii)

$\lambda' = \frac{27}{32}\lambda$

Question7

The de Broglie wavelengths of a proton and an α particle are λ and 2λ respectively. The ratio of the velocities of proton and α particle will be :
[1-Feb-2024 Shift 1]

Options:

A. 1 : 8

B. 1 : 2

C. 4 : 1

D. 8 : 1

Answer: D

Solution:

$$\lambda = \frac{h}{p} = \frac{h}{mv} \Rightarrow v = \frac{h}{m\lambda}$$

$$\frac{v_p}{v_\alpha} = \frac{m_\alpha}{m_p} \times \frac{\lambda_\alpha}{\lambda_p}$$

$$= 4 \times 2 = 8$$

Question8

Monochromatic light of frequency 6×10^{14} Hz is produced by a laser. The power emitted is 2×10^{-3}W. How many photons per second on an average, are emitted by the source ?
(. Given $h = 6.63 \times 10^{-34}$ Js)
[1-Feb-2024 Shift 2]

Options:

A. 9×10^{18}

B. 6×10^{15}

C. 5×10^{15}

D. 7×10^{16}

Answer: C

Solution:

$$P = nh\nu$$

$$n = \frac{P}{h\nu} = \frac{2 \times 10^{-3}}{6.63 \times 10^{-34} \times 6 \times 10^{14}}$$

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

Question9

From the photoelectric effect experiment, following observations are

made. Identify which of these are correct
A. The stopping potential depends only on the work function of the metal.
B. The saturation current increases as the intensity of incident light increases.
C. The maximum kinetic energy of a photo electron depends on the intensity of the incident light.
D. Photoelectric effect can be explained using wave theory of light.
Choose the correct answer from the options given below:
[24-Jan-2023 Shift 1]

Options:

A. B, C only

B. A, C, D only

C. B only

D. A, B, D only

Answer: C

Solution:

Solution:
(A) Stopping potential depends on both frequency of light and work function.
(B) Saturation current ∝ intensity of light
(C) Maximum KE depends on frequency
(D) Photoelectric effect is explained using particle theory

Question10

An α-particle, a proton and an electron have the same kinetic energy. Which one of the following is correct in case of their De-Broglie wavelength:
[24-Jan-2023 Shift 2]

Options:

A. $\lambda_\alpha > \lambda_p > \lambda_e$

B. $\lambda_\alpha < \lambda_p < \lambda_e$

C. $\lambda_\alpha = \lambda_p = \lambda_e$

D. $\lambda_\alpha > \lambda_p < \lambda_e$

Answer: B

Solution:

$\lambda_D = \frac{h}{p} = \frac{h}{\sqrt{2mK}}$

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

$\because m_\alpha > m_p > m_e$

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

Question11

Electron beam used in an electron microscope, when accelerated by a voltage of 20 kV. has a de-Broglie wavelength of λ_o. If the voltage is increased to 40 kV. then the de-Broglie wavelength associated with the electron beam would be:
[25-Jan-2023 Shift 1]

Options:

A. $3\lambda_0$

B. $9\lambda_0$

C. $\frac{\lambda_0}{2}$

D. $\frac{\lambda_0}{\sqrt{2}}$

Answer: D

Solution:

Solution:

When electron is accelerated through potential difference V , then

K.E. = eV

$\Rightarrow \lambda = \frac{h}{\sqrt{2m(KE)}} = \frac{h}{\sqrt{2meV}}$

$\therefore \lambda \alpha \frac{1}{\sqrt{V}}$

$\therefore \frac{\lambda}{\lambda_0} = \sqrt{\frac{20}{40}}$

$\therefore \lambda = \frac{\lambda_0}{\sqrt{2}}$

Question12

Given below are two statements :
Statement I : Stopping potential in photoelectric effect does not depend on the power of the light source.
Statement II : For a given metal, the maximum kinetic energy of the photoelectron depends on the wavelength of the incident light.
In the light of above statements, choose the most appropriate answer from the options given below.

Options :
[25-Jan-2023 Shift 2]

Options:

A. Statement I is incorrect but statement II is correct

B. Both Statement I and Statement II are incorrect

C. Statement I is correct but statement II is incorrect

D. Both statement I and statement II are correct

Answer: D

Solution:

Stopping potential $V_S = \frac{KE_{max}}{e}$

$V_S = \frac{\frac{hC}{\lambda} - \varphi}{e}$

Stopping potential does not depend on intensity or power of light used, it only depends on frequency or wavelength of incident light.
So both statements I and II are correct

Question13

The threshold wavelength for photoelectric emission from a material is 5500Å. Photoelectrons will be emitted, when this material is illuminated with monochromatic radiation from a
A. 75W infra-red lamp
B. 10W infra-red lamp
C. 75W ultra-violet lamp
D. 10W ultra-violet lamp
Choose the correct answer from the options given below :
[29-Jan-2023 Shift 1]

Options:

A. B and C only

B. A and D only

C. C only

D. C and D only

Answer: D

Solution:

$\lambda < 5500Å$ for photoelectric emission
$\lambda_{uv} < 5500Å$

Question14

The ratio of de-Broglie wavelength of an α-particle and a proton accelerated from rest by the same potential is $\frac{1}{\sqrt{m}}$, the value of m is
[29-Jan-2023 Shift 2]

Options:

A. 4

B. 16

C. 8

D. 2

Answer: C

Solution:

$$\frac{\lambda_\alpha}{\lambda_p} = \frac{\frac{h}{\sqrt{2m_\alpha q_\alpha V}}}{\frac{h}{\sqrt{2m_p q_p V}}}$$

$$\frac{\lambda_\alpha}{\lambda_p} = \sqrt{\frac{1}{8}} \quad m = 8$$

Question15

A small object at rest, absorbs a light pulse of power 20 mW and duration 300 ns. Assuming speed of light as 3×10^8 m / s. the momentum of the object becomes equal to :
[30-Jan-2023 Shift 1]

Options:

A. 0.5×10^{-17} kg m / s

B. 2×10^{-17} kg m / s

C. 3×10^{-17} kg m / s

D. 1×10^{-17} kg m / s

Answer: B

Solution:

$$\text{Momentum} = \frac{\text{Energy}}{C}$$

$= \frac{\text{Power} \times \text{time}}{C}$

$= \frac{(20 \times 10^{-3} w)(300 \times 10^{-9} s)}{3 \times 10^{8} m/s}$

$= 2 \times 10^{-17} kg - m/s$

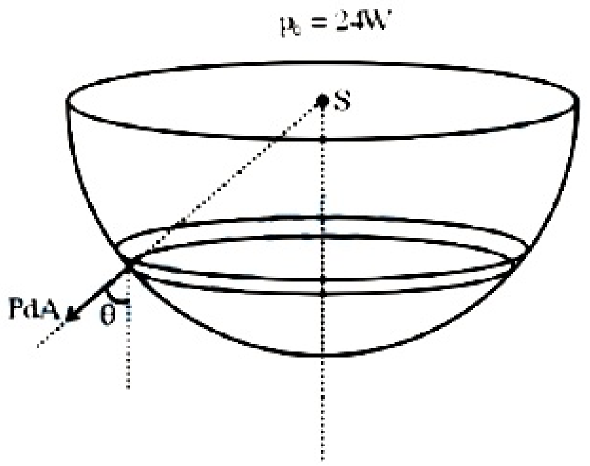
Question16

A point source of light is placed at the centre of curvature of a hemispherical surface. The source emits a power of 24W The radius of curvature of hemisphere is 10 cm and the inner surface is completely reflecting. The force on the hemisphere due to the light falling on it is ________ $\times 10^{-8}$N

[30-Jan-2023 Shift 1]

Answer: 4

Solution:



$\text{Force} = \int PdA \cos\theta$

$= \frac{2I}{C}\int dA \cos\theta = \frac{2I}{C}\pi R^2 = 2\frac{p_0}{4\pi R^2}\cdot\frac{\pi R^2}{C}$

$= \frac{p_0}{2C} = \frac{24}{2 \times 3 \times 10^8} = 4 \times 10^{-8} N$ (Ans)

Question17

An electron accelerated through a potential difference V_1 has a de-Broglie wavelength of λ. When the potential is changed to V_2, its de-Broglie wavelength increases by 50%. The value of $\left(\frac{V_1}{V_2}\right)$ is equal to :

[30-Jan-2023 Shift 2]

Options:

A. 3

B. $\frac{9}{4}$

C. $\frac{3}{2}$

D. 4

Answer: B

Solution:

$$KE = \frac{P^2}{2m}, \quad P = \frac{h}{\lambda}$$

$$eV_1 = \frac{\left(\frac{h}{\lambda}\right)^2}{2m}$$

$$eV_2 = \frac{\left(\frac{h}{1.5\lambda}\right)^2}{2m}$$

$$\frac{V_1}{V_2} = (1.5)^2 = \frac{9}{4}$$

Question18

If a source of electromagnetic radiation having power 15 kW produces 10^{16} photons per second, the radiation belongs to a part of spectrum is. (Take Planck constant $h = 6 \times 10^{-34}$ Js)
[31-Jan-2023 Shift 1]

Options:

A. Micro waves

B. Ultraviolet rays

C. Gamma rays

D. Radio waves

Answer: C

Solution:

$$\text{Energy of one photon} = \frac{\text{Power}}{\text{Photon frequency}}$$

$$E = h\nu = \frac{15 \times 10^3}{10^{16}}$$

$$\nu = \frac{15 \times 10^{-13}}{6 \times 10^{-34}} = 2.5 \times 10^{21}$$

So gamma Rays. Option 3

Question19

If the two metals A and B are exposed to radiation of wavelength 350 nm. The work functions of metals A and B are 4.8 eV and 2.2 eV. Then choose the correct option
[31-Jan-2023 Shift 2]

Options:

A. Metal B will not emit photo-electrons

B. Both metals A and B will emit photo-electrons

C. Both metals A and B will not emit photoelectrons

D. Metal A will not emit photo-electrons

Answer: D

Solution:

Solution:

$\varphi = \frac{hc}{\lambda} = \frac{1240}{350}\,\text{eV} = 3.54\,\text{eV}$

∴ Only metal B will emit photoelectron.

Question20

A proton moving with one tenth of velocity of light has a certain de Broglie wavelength of λ. An alpha particle having certain kinetic energy has the same de-Brogle wavelength λ. The ratio of kinetic energy of proton and that of alpha particle is:
[1-Feb-2023 Shift 1]

Options:

A. 2 : 1

B. 4 : 1

C. 1 : 2

D. 1 : 4

Answer: B

Solution:

$$KE = \frac{p^2}{2m} = \frac{h^2}{2m\lambda^2}$$

$$\frac{KE_p}{KE_\alpha} = \frac{m_\alpha}{m_p} = 4 : 1$$

Question21

The threshold frequency of metal is f_0. When the light of frequency $2f_0$ is incident on the metal plate, the maximum velocity of photoelectron is v_1. When the frequency of incident radiation is increased to $5f_0$. the maximum velocity of photoelectrons emitted is v_2. The ratio of v_1 to v_2 is:
[1-Feb-2023 Shift 2]

Options:

A. $\frac{v_1}{v_2} = \frac{1}{2}$

B. $\frac{v_1}{v_2} = \frac{1}{8}$

C. $\frac{v_1}{v_2} = \frac{1}{16}$

D. $\frac{v_1}{v_2} = \frac{1}{4}$

Answer: A

Solution:

$K_{max} = hf - hf_0$
For $f = 2f_0$
$\frac{1}{2}mV_1{}^2 = 2hf_0 - hf f_0 = hf_0$
For $f = 5f_0$
$\frac{1}{2}mV_2{}^2 = 5hf_0 - hf_0 = 4hf_0$
$\frac{V_1}{V_2} = \frac{1}{2}$

Question22

The kinetic energy of an electron, α-particle and a proton are given as 4K, 2K and K respectively. The de-Broglie wavelength associated with electron (λe), α-particle (λα) and the proton (λp) are as follows :
[6-Apr-2023 shift 1]

Options:

A. $\lambda\alpha > \lambda p > \lambda e$

B. $\lambda\alpha = \lambda p > \lambda e$

C. $\lambda\alpha = \lambda p < \lambda e$

D. $\lambda\alpha < \lambda p < \lambda e$

Answer: D

Solution:

Solution:
According to De-Broglie, Momentum $P = \frac{h}{\lambda}$, where h is plank's constant and λ is wavelength.
Also, relation between Kinetic energy (KE) and momentum((P) is given by: $P = \sqrt{2mKE}$
Now, $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mKE}}$
$\lambda_e = \frac{h}{\sqrt{2m_e KE_e}} = \frac{h}{\sqrt{2m_e \times 4k}} = \frac{h}{\sqrt{8m_e k}}$
$\lambda_p = \frac{h}{\sqrt{2m_p KE_p}} = \frac{h}{\sqrt{2m_p k}}$
$\lambda_\alpha = \frac{h}{\sqrt{2m_\alpha KE_\alpha}} = \frac{h}{\sqrt{2m_\alpha \cdot 4k}} = \frac{h}{\sqrt{2 \times 2m_p \cdot 2k}} = \frac{h}{\sqrt{8m_p k}}$
From the above data, $\lambda_\alpha < \lambda_p < \lambda_e$

Question23

The work functions of Aluminium and Gold are 4.1 eV and and 5.1 eV respectively. The ratio of the slope of the stopping potential versus frequency plot for Gold to that of Aluminium is [6-Apr-2023 shift 2]

Options:

A. 1

B. 2

C. 1.24

D. 1.5

Answer: A

Solution:

Solution:
Using $KE_{max} = eV_s = hf - \varphi_0$
where φ_0 is work function, V_s is stopping potential and f is frequency
or $V_s = \frac{h}{e}f - \frac{\varphi_0}{e}$
therefore the slope m will be same for all graphs and will be independent of φ_0.

Question24

Proton (P) and electron (e) will have same de-Broglie wavelength when the ratio of their momentum is (assume, $m_p = 1849m_e$): [8-Apr-2023 shift 1]

Options:

A. 1 : 43

B. 43 : 1

C. 1 : 1849

D. 1 : 1

Answer: D

Solution:

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

$\lambda_p = \lambda_e$

$\frac{h}{p_p} = \frac{h}{p_e} \Rightarrow \frac{p_p}{p_e} = 1$

Question25

In photoelectric effect
A. The photocurrent is proportional to the intensity of the incident radiation.
B. Maximum Kinetic energy with which photoelectrons are emitted depends on the intensity of incident light.
C. Max K.E with which photoelectrons are emitted depends on the frequency of incident light.
D. The emission of photoelectrons require a minimum threshold intensity of incident radiation.
E. Max. K.E of the photoelectrons is independent of the frequency of the incident light.
Choose the correct answer from the options given below:
[8-Apr-2023 shift 2]

Options:

A. B and C only

B. A and C only

C. A and E only

D. A and B only

Answer: B

Solution:

$h\nu = \varphi + (KE)_{max}$
$(KE)_{max} = h\nu - \varphi$

Question26

The de Broglie wavelength of a molecule in a gas at room temperature (300K) is λ_1. If the temperature of the gas is increased to 600K, then the de Broglie wavelength of the same gas molecule becomes [10-Apr-2023 shift 1]

Options:

A. $2\lambda_1$

B. $\frac{1}{\sqrt{2}}\lambda_1$

C. $\sqrt{2}\lambda_1$

D. $\frac{1}{2}\lambda_1$

Answer: B

Solution:

$$\lambda = \frac{h}{\sqrt{3\,mK(T)}}$$

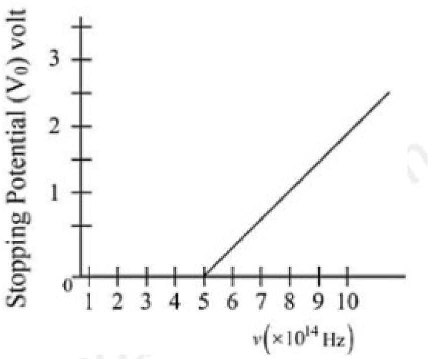
$$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{T_2}{T_1}}$$

$$\lambda_2 = \lambda_1\sqrt{\frac{T_1}{T_2}}$$

$$= \lambda_1\sqrt{\frac{300}{600}} = \frac{\lambda_2}{\sqrt{2}}$$

Question27

The variation of stopping potential (V_0) as a function of the frequency (v) of the incident light for a metal is shown in figure. The work function of the surface is



[10-Apr-2023 shift 2]

Options:

A. 2.07 eV

B. 18.6 eV

C. 2.98 eV

D. 1.36 eV

Answer: A

Solution:

Solution:

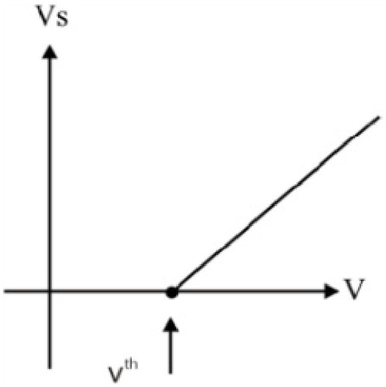
Work function $(\varphi) = hv^{th}$

$= 6.6 \times 10^{-34} \times 5 \times 10^{14}$

$= 33 \times 10^{-20}$

$\varphi = 3.3 \times 10^{-19} J$

$= \frac{3.3 \times 10^{-19}}{1.6 \times 10^{-19}} ev \Rightarrow 2.07$



Question28

A metallic surface is illuminated with radiation of wavelength λ, the stopping potential is V_0. If the same surface is illuminated with radiation of wavelength 2λ, the stopping potential becomes $\frac{V_0}{4}$. The threshold wavelength for this metallic surface will be [11-Apr-2023 shift 1]

Options:

A. $\frac{3}{2}\lambda$

B. 4λ

C. 3λ

D. $\frac{\lambda}{4}$

Answer: C

Solution:

Solution:

$E = K \cdot E + \varphi_0$

Now

$\frac{hc}{\lambda} = ev_0 + \varphi_0 \ldots (1)$

And $\frac{hc}{2\lambda} = \frac{eV_0}{4} + \varphi_0 \ldots (2)$

$(2) \times 4 \ldots (1)$

$\frac{2hc}{\lambda} - \frac{hc}{\lambda} = 0 + (4\varphi_0 - \varphi_0)$

$\frac{hc}{\lambda} = 3\varphi_0$

$\frac{hc}{\lambda} = 3\frac{hc}{\lambda_0}$

$\lambda_0 = 3\lambda$

Question29

The ratio of the de-Broglie wavelengths of proton and electron having same Kinetic energy: (Assume $m_p = m_e \times 1849$) [11-Apr-2023 shift 2]

Options:

A. 1 : 62

B. 1 : 30

C. 1 : 43

D. 2 : 43

Answer: C

Solution:

Solution:

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

$\frac{\lambda_P}{\lambda_e} = \sqrt{\frac{m_e}{m_p}} = \sqrt{\frac{m_e}{1840\,me}} = \frac{1}{\sqrt{1840}}$

$\frac{\lambda_P}{\lambda_e} = \frac{1}{43}$ Ans. (3)

Ans. (3)

Question30

A proton and an α-particle are accelerated from rest by 2V and 4V potentials, respectively. The ratio of their de-Broglie wavelength is : [12-Apr-2023 shift 1]

Options:

A. 2 : 1

B. 4 : 1

C. 8 : 1

D. 16 : 1

Answer: B

Solution:

Solution:

De Broglie wavelength $\lambda = \dfrac{h}{\sqrt{2mqV}}$

$m_\alpha = 4m \rightarrow 4V$

$m_p = m \rightarrow 2V$

$\lambda = \dfrac{h}{\sqrt{2mKE}}$

$\lambda_p = \dfrac{h}{\sqrt{2mq(2V)}} \ldots .(1), \quad \lambda_\alpha = \dfrac{h}{\sqrt{4mq(4V)}}$

$\dfrac{\lambda_p}{\lambda_\alpha} = \dfrac{h}{\sqrt{2mq(2V)}} \times \dfrac{\sqrt{4mq(4V)}}{h}$

$\dfrac{\lambda_p}{\lambda_\alpha} = 4 \quad \Rightarrow \quad \dfrac{\lambda_p}{\lambda_\alpha} = 4 : 1$

Question31

The difference between threshold wavelengths for two metal surfaces A and B having work function $\varphi_A = 9\,eV$ and $\varphi_B = 4.5\,eV$ in nm is:
{ Given, hc = 1242 eV nm }
[13-Apr-2023 shift 1]

Options:

A. 276

B. 264

C. 540

D. 138

Answer: D

Solution:

Solution:

$\varphi = \dfrac{hc}{\lambda}$

$\lambda_A = \dfrac{1242}{9} = 138\,nm$

$\lambda_B = \dfrac{1242}{4.5} = 276\,nm$

$\lambda_B - \lambda_A = 276 - 138 = 138\,nm$

Question32

The de Broglie wavelength of an electron having kinetic energy E is λ. If the kinetic energy of electron becomes $\frac{E}{4}$, then its de-Broglie wavelength will be :
[15-Apr-2023 shift 1]

Options:

A. $\frac{\lambda}{\sqrt{2}}$

B. 2λ

C. $\frac{\lambda}{2}$

D. $\sqrt{2}\lambda$

Answer: B

Solution:

Solution:

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

$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{E_2}{E_1}} = \sqrt{\frac{1}{4}} = \frac{1}{2}$

$\lambda_2 = 2\lambda$

Question33

When light of frequency twice the threshold frequency is incident on the metal plate, the maximum velocity of emitted electron is v_1. When the frequency of incident radiation is increased to five times the threshold value, the maximum velocity of emitted electron becomes v_2. If $v_2 = xv_1$, the value of x will be
[24-Jun-2022-Shift-1]

Answer: 2

Solution:

Let us say that work function is φ

$\Rightarrow 2\varphi = \varphi + \frac{1}{2}mv_1^2 \ldots\ldots$ (1

and $5\varphi = \varphi + \frac{1}{2}mv_2^2 \ldots.$ (2

From (1) and (2)

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

Question34

The de Broglie wavelengths for an electron and a photon are λ_e and λ_p respectively. For the same kinetic energy of electron and photon, which of the following presents the correct relation between the de Broglie wavelengths of two ?
[28-Jun-2022-Shift-1]

Options:

A. $\lambda_p \propto \lambda_e^2$

B. $\lambda_p \propto \lambda_e$

C. $\lambda_p \propto \sqrt{\lambda_e}$

D. $\lambda_p \propto \sqrt{\frac{1}{\lambda_e}}$

Answer: A

Solution:

Solution:
$\lambda_p = \frac{h}{p} = \frac{hc}{E}$...... (i)
$\lambda_e = \frac{h}{\sqrt{2mE}}$...... (ii)
From (i) and (ii)
$\lambda_p \propto \lambda_e^2$

Question35

The light of two different frequencies whose photons have energies 3.8 eV and 1.4 eV respectively, illuminate a metallic surface whose work function is 0.6 eV successively. The ratio of maximum speeds of emitted electrons for the two frequencies respectively will be :
[24-Jun-2022-Shift-2]

Options:

A. 1 : 1

B. 2 : 1

C. 4 : 1

D. 1 : 4

Answer: B

Solution:

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

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

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

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

Question36

Let K_1 and K_2 be the maximum kinetic energies of photo-electrons emitted when two monochromatic beams of wavelength λ 1 and λ_2, respectively are incident on a metallic surface. If $\lambda_1 = 3\lambda_2$ then : [28-Jun-2022-Shift-2]

Options:

A. $K_1 > \frac{K_2}{3}$

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

C. $K_1 = \frac{K_2}{3}$

D. $K_2 = \frac{K_1}{3}$

Answer: B

Solution:

Solution:

$K_1 = \frac{hc}{\lambda_1} - \varphi = \frac{hc}{3\lambda_2} - \varphi$

and $K_2 = \frac{hc}{\lambda_2} - \varphi$

from (i) and (ii) we can say

$3K_1 = K_2 - 2\varphi$

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

Question37

Given below are two statements :
Statement I : Davisson-Germer experiment establishes the wave nature of electrons.
Statement II : If electrons have wave nature, they can interfere and show diffraction.
In the light of the above statements choose the correct answer from the

option given below :
[25-Jun-2022-Shift-1]

Options:

A. Both Statement I and Statement II are true.

B. Both Statement I and Statement II are false.

C. Statement I is true but Statement II is false.

D. Statement I is false but Statement II is true.

Answer: B

Solution:

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

Question38

Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R:
Assertion A: The photoelectric effect does not takes place, if the energy of the incident radiation is less than the work function of a metal.
Reason R : Kinetic energy of the photoelectrons is zero, if the energy of the incident radiation is equal to the work function of a metal.
In the light of the above statements, choose the most appropriate answer from the options given below.
[29-Jun-2022-Shift-1]

Options:

A. Both A and R are correct and R is the correct explanation of A.

B. Both A and R are correct but R is not the correct explanation of A.

C. A is correct but R is not correct.

D. A is not correct but R is correct.

Answer: B

Solution:

To free the electron from metal surface minimum energy required, is equal to the work function of that metal.
So Assertion A, is correct.
$hv = w_0 + K.E._{max}$
if $hv = w_0$
$\Rightarrow K.E._{max} = 0$
Hence reason R, is correct, But R is not the correct explanation of A.
When energy of incident radiation is equal to the work function of the metal, then the KE of photoelectrons would be zero. But this statement does not comment on the situation when energy is less than the work function.

Question39

A proton, a neutron, an electron and an α particle have same energy. If λ_p, λ_n, λ_e and λ_a are the de Broglie's wavelengths of proton, neutron, electron and α particle respectively, then choose the correct relation from the following:
[25-Jun-2022-Shift-2]

Options:

A. $\lambda_p = \lambda_n > \lambda_e > \lambda_a$

B. $\lambda_a < \lambda_n < \lambda_p < \lambda_e$

C. $\lambda_e < \lambda_p = \lambda_n > \lambda_a$

D. $\lambda_e = \lambda_p = \lambda_n = \lambda_a$

Answer: D

Solution:

Solution:

de Broglie wavelength $\lambda = \frac{h}{p} \Rightarrow \lambda = \frac{h}{\sqrt{2mK}}$

Where K : kinetic energy

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

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

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

Question40

The electric field at a point associated with a light wave is given by
$E = 200[\sin(6 \times 10^{15})t + \sin(9 \times 10^{15})t]V^{-1}$
Given : $h = 4.14 \times 10^{-15}$ eVs
If this light falls on a metal surface having a work function of 2.50 eV, the maximum kinetic energy of the photoelectrons will be
[29-Jun-2022-Shift-2]

Options:

A. 1.90 eV

B. 3.27 eV

C. 3.60 eV

D. 3.42 eV

Answer: D

Solution:

Frequency of EM waves $= \frac{6}{2\pi} \times 10^{15}$ and $\frac{9}{2\pi} \times 10^{15}$

Energy of one photon of these waves

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

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

$= 3.95$ eV and 5.93 eV

⇒ Energy of maximum energetic electrons

$= 5.93 - 2.50 = 3.43$ eV

Question41

An electron with speed v and a photon with speed c have the same de-Broglie wavelength. If the kinetic energy and momentum of electron are E_e and p_e and that of photon are E_{ph} and p_{ph} respectively. Which of the following is correct?
[26-Jun-2022-Shift-1]

Options:

A. $\frac{E_e}{E_{ph}} = \frac{2c}{v}$

B. $\frac{E_e}{E_{ph}} = \frac{v}{2c}$

C. $\frac{p_e}{p_{ph}} = \frac{2c}{v}$

D. $\frac{p_e}{p_{ph}} = \frac{v}{2c}$

Answer: B

Solution:

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

Now, A/Q, $\frac{h}{P_e} = \frac{h}{P_{photon}} \Rightarrow P_e = P_{photon}$ …….. (i)

Now, $K_e = \frac{1}{2} M v^2 = \frac{Pv}{2}$

$K_{ph} = mc^2 = Pc$…. (ii)

$\frac{K_e}{K_{eq}} = \frac{v}{2c}$

Question42

The stopping potential for photoelectrons emitted from a surface

illuminated by light of wavelength 6630Å is 0.42V. If the threshold frequency is $x \times 10^{13}$ / s, where x is____ (nearest integer).
(Given, speed light = 3×10^{8}m / s, Planck's constant = 6.63×10^{-34}Js)
[26-Jun-2022-Shift-2]

Answer: 35

Solution:

$$\frac{hc}{\lambda} - \varphi = KE = eV_0$$
$$\Rightarrow \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{6630 \times 10^{-10}} - 6.63 \times 10^{-34} f_{th} = 1.6 \times 10^{-19} \times 0.4$$
$$\Rightarrow f_{th} \simeq 35.11 \times 10^{13} H$$

Question43

An α particle and a carbon 12 atom has same kinetic energy K. The ratio of their de-Broglie wavelengths ($\lambda_{\alpha} : \lambda_{C12}$) is :
[27-Jun-2022-Shift-1]

Options:

A. $1 : \sqrt{3}$

B. $\sqrt{3} : 1$

C. 3 : 1

D. $2 : \sqrt{3}$

Answer: B

Solution:

$$K_{\alpha} = K_{C}$$
$$\frac{{p_{\alpha}}^{2}}{2m_{\alpha}} = \frac{{p_{C}}^{2}}{2m_{C}}$$
$$\frac{p_{\alpha}}{p_{C}} = \sqrt{\frac{m_{\alpha}}{m_{C}}}$$
So $\frac{\lambda_{\alpha}}{\lambda_{C}} = \frac{h / p_{\alpha}}{h / p_{C}} = \sqrt{\frac{m_{C}}{m_{\alpha}}}$

So $\frac{\lambda_{\alpha}}{\lambda_{C}} = \sqrt{3}$

Question44

Given below are two statements :
Statement I : In hydrogen atom, the frequency of radiation emitted when an electron jumps from lower energy orbit ($E.E_1$) to higher energy orbit (E_2), is given as $hf = E_1 - E_2$
Statement II : The jumping of electron from higher energy orbit (E_2) to lower energy orbit (E_1) is associated with frequency of radiation given as $f = (E_2 - E_1) / h$
This condition is Bohr's frequency condition.
In the light of the above statements, choose the correct answer from the options given below :
[27-Jun-2022-Shift-2]

Options:

A. Both Statement I and Statement II are true.

B. Both Statement I and Statement II are false.

C. Statement I is correct but Statement II is false.

D. Statement I is incorrect but Statement II is true.

Answer: D

Solution:

Solution:
Radiation is not emitted but absorbed when an electron jumps from low energy to high energy.
Also, $E_2 - E_1$ is the energy of photon
$\Rightarrow E_2 - E_1 = hf$
$\Rightarrow f = \frac{E_2 - E_1}{h}$

Question45

A metal exposed to light of wavelength 800nm and and emits photoelectrons with a certain kinetic energy. The maximum kinetic energy of photo-electron doubles when light of wavelength 500nm is used. The work function of the metal is : (Take $hc = 1230eV - nm$).
[25-Jul-2022-Shift-1]

Options:

A. 1.537eV

B. 2.46eV

C. 0.615eV

D. 1.23eV

Answer: C

Solution:

$\because K_m = \dfrac{hc}{\lambda} - \varphi$

$\Rightarrow K = \dfrac{1230}{800} - \varphi$

and, $2K = \dfrac{1230}{500} - \varphi$

$\Rightarrow 2 \times \dfrac{1230}{800} - 2\varphi = \dfrac{1230}{500} - \varphi$

$\Rightarrow \varphi = 0.615 eV$

Question46

The energy band gap of semiconducting material to produce violet (wavelength = 4000$\mathring{A}$) LED is eV. (Round off to the nearest integer). [25-Jul-2022-Shift-1]

Answer: 3

Solution:

Energy corresponding to wavelength $4000\mathring{A}$

$E = \dfrac{hc}{\pi}$

$= \dfrac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{4000 \times 10^{-10} \times 1.6 \times 10^{-19}} eV$

$= \dfrac{12400}{4000}$

$= 3.1 eV$

$\approx 3 eV$

Question47

The ratio of wavelengths of proton and deuteron accelerated by potential V_p and V_d is $1 : \sqrt{2}$. Then the ratio of V_p to V_d will be : [25-Jul-2022-Shift-2]

Options:

A. 1 : 1

B. $\sqrt{2} : 1$

C. 2 : 1

D. 4 : 1

Answer: D

Solution:

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

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

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

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

Question48

A parallel beam of light of wavelength 900 nm and intensity $100Wm^{-2}$ is incident on a surface perpendicular to the beam. The number of photons crossing $1cm^2$ area perpendicular to the beam in one second is :
[26-Jul-2022-Shift-1]

Options:

A. 3×10^{16}

B. 4.5×10^{16}

C. 4.5×10^{17}

D. 4.5×10^{20}

Answer: B

Solution:

$\lambda = 900\,nm$
$I = 100W / m^2$
$A = 10^{-4}$
$\Rightarrow P = 10^{-2}W$
⇒ Number of photons incident per second
$= \frac{10^{-2}\lambda}{hc}$
$= \frac{9 \times 10^{-11} \times 10^2}{6.63 \times 10^{-34} \times 3 \times 10^8} \simeq 4.5 \times 10^{16}$

Question49

With reference to the observations in photo-electric effect, identify the

correct statements from below
(A) The square of maximum velocity of photoelectrons varies linearly with frequency of incident light.
(B) The value of saturation current increases on moving the source of light away from the metal surface.
(C) The maximum kinetic energy of photo-electrons decreases on decreasing the power of LED (light emitting diode) source of light.
(D) The immediate emission of photo-electrons out of metal surface can not be explained by particle nature of light/electromagnetic waves.
(E) Existence of threshold wavelength can not be explained by wave nature of light / electromagnetic waves.
Choose the correct answer from the options given below :
[27-Jul-2022-Shift-2]

Options:

A. (A) and (B) only

B. (A) and (E) only

C. (C) and (E) only

D. (D) and (E) only

Answer: B

Solution:

Solution:

$\because \frac{1}{2}m{v_m}^2 = h\nu - \varphi$

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

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

Question50

The equation $\lambda = \frac{1.227}{x}$ nm can be used to find the de-Brogli wavelength of an electron. In this equation x stands for:
Where
m = mass of electron
P− momentum of electron
K = Kinetic energy of electron
V = Accelerating potential in volts for electron
[28-Jul-2022-Shift-1]

Options:

A. $\sqrt{mK}$

B. $\sqrt{P}$

C. $\sqrt{K}$

D. $\sqrt{V}$

Answer: D

Solution:

Solution:

$\because \lambda = \frac{1.227}{\sqrt{V}} nm$

$\Rightarrow x = \sqrt{V}$

Question51

Two streams of photons, possessing energies equal to five and ten times the work function of metal are incident on the metal surface successively. The ratio of maximum velocities of the photoelectron emitted, in the two cases respectively, will be
[28-Jul-2022-Shift-2]

Options:

A. 1 : 2

B. 1 : 3

C. 2 : 3

D. 3 : 2

Answer: C

Solution:

Solution:

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

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

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

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

Question52

The kinetic energy of emitted electron is E when the light incident on the metal has wavelength λ. To double the kinetic energy, the incident light must have wavelength:
[29-Jul-2022-Shift-1]

Options:

A. $\frac{hc}{E\lambda - hc}$

B. $\frac{hc\lambda}{E\lambda + hc}$

C. $\frac{h\lambda}{E\lambda + hc}$

D. $\frac{hc\lambda}{E\lambda - hc}$

Answer: B

Solution:

Solution:

$E = \frac{hc}{\lambda} - \varphi - \quad (i)$

$2E = \frac{hc}{\lambda'} - \varphi - \quad (ii)$

(ii) − (i)

$E = hc\left(\frac{1}{\lambda'} - \frac{1}{\lambda}\right)$

$\Rightarrow \lambda' = \frac{hc\lambda}{E\lambda + hc}$

Question53

An α particle and a proton are accelerated from rest through the same potential difference. The ratio of linear momenta acquired by above two particles will be:
[29-Jul-2022-Shift-2]

Options:

A. $\sqrt{2} : 1$

B. $2\sqrt{2} : 1$

C. $4\sqrt{2} : 1$

D. $8 : 1$

Answer: B

Solution:

Solution:

We know,

$\text{Momentum}(p) = \sqrt{2mE_k}$

and $E_k = qV_{acc}$

$\therefore p = \sqrt{2mqV_{acc}}$

Both α particle and proton are passed through same potential difference.

$\therefore (V_{acc})_\alpha = (V_{acc})_p = v$

$\therefore p_\alpha = \sqrt{2m_\alpha q_\alpha v}$

$p_p = \sqrt{2m_p q_p v}$

$\therefore \frac{p_\alpha}{p_p} = \sqrt{\frac{m_\alpha q_\alpha}{m_p q_p}}$

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

$= \sqrt{\frac{8}{1}}$

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

Question54

Two stream of photons, possessing energies equal to twice and ten times the work function of metal are incident on the metal surface successively. The value of ratio of maximum velocities of the photoelectrons emitted in the two respective cases is x : y. The value of x is ....
[26 Feb 2021 Shift 2]

Answer: 1

Solution:

Given, first incident energy, $E_{i_1} = 2$ (work function φ_0) Second incident energy, $E_{i_2} = 10\varphi_0$
If v_1 and v_2 be the respective maximum velocities in two cases, then by using the concept of photoelectric effect,
$KE = E_i - \varphi_0$
$KE = E_i - \varphi_0$
$\therefore\ 1/2mv_1^2 = 2\varphi_0 - \varphi_0 = \varphi_0$ . . . (i)
and $1/2mv_2^2 = 10\varphi_0 - \varphi_0 = 9\varphi_0$ . . . (ii)
On dividing Eq. (i) by Eq. (ii), we get

$\left(\frac{v_1}{v_2}\right)^2 = \frac{1}{9}$

t $\frac{v_1}{v_2} = \frac{1}{3} = \frac{x}{y}$

$\therefore\ x = 1$

Question55

The stopping potential for electrons emitted from a photosensitive surface illuminated by light of wavelength 491nm is 0.710V . When the incident wavelength is changed to a new value, the stopping potential is 1.43V . The new wavelength is
[25 Feb 2021 Shift 2]

Options:

A. 309nm

B. 329nm

C. 382nm

D. 400nm

Answer: C

Solution:

Given, stopping potential $(V_1) = 0.710V$
Incident wavelength of electrons $(\lambda_1) = 491nm$
$= 491 \times 10^{-9}m$
Let λ_2 will be the new incident wavelength of electrons.
Stopping potential $(V_2) = 1.43V$
As, energy $(E) = \frac{1240}{\lambda_1} = \varphi_0 + eV$
where, φ_0 is work-function and V is applied potential
$\therefore E_1 = \frac{1240}{491} = \varphi_0 + 0.71 - 1.43 \ldots$ (i)
and $E_2 = \frac{1240}{\lambda_2} = \varphi_0 + 1.43 \ldots$ (ii)
Now, subtracting Eqs. (i) from (ii), we get
$E_2 - E_1 = 1240\left(\frac{1}{\lambda_2} - \frac{1}{491}\right) = 0.72$
$\Rightarrow \frac{1}{\lambda_2} = 0.00058 + 0.00204 = 0.00262$
$\therefore \lambda_2 = 381.7nm$
$\lambda_2 = 382nm$

Question56

Given below are two statements: One is labelled as Assertion A and the other is labelled as Reason R.
Assertion A An electron microscope can achieve better resolving power than an optical microscope.
Reason R The de-Broglie's wavelength of theelectrons emitted from an electron gun is much less than wavelength of visible light.
In the light of the above statements, choose the correct answer from the options given below.
[26 Feb 2021 Shift 1]

Options:

A. A is true but R is false.

B. Both A and R are true and R is the correct explanation of A.

C. Both A and R are true but R is not the correct explanation of A.

D. A is false but R is true.

Answer: B

Solution:

As we know that,
Resolving power of microscope $= \frac{1}{\Delta\theta} = \frac{2u\sin\theta}{\lambda}$
i.e. resolving power $\propto \frac{1}{\lambda}$
and since, wavelength of electron emitted $(\lambda_e) <$ wavelength of visible light (λ_v)
∴ Resolving power of electron microscope > Resolving power of optical microscope.
Hence, option (b) is the correct.

Question57

The wavelength of an X-ray beam is 10Å. The mass of a fictitious particle having the same energy as that of the X-ray photons is $\frac{x}{3}$hkg. The value of x is .... (h = Planck's constant) [25 Feb 2021 Shift 2]

Answer: 10

Solution:

Given, wavelength of X-rays,
$\lambda = 10\text{Å} = 10 \times 10^{-10}\text{m}$
Speed of light in free space, $c = 3 \times 10^8 \text{m / s}$
Since, energy $(E) = \frac{hc}{\lambda} = mc^2$ . . . (i)
$\Rightarrow m = \frac{h}{d\lambda} = \frac{h}{3 \times 10^8 \times 10 \times 10^{-10}} = \frac{h}{3 \times 10^{-1}} = \frac{10h}{3}\text{kg}$
$\therefore x = 10$

Question58

An electron of mass m_e and a proton of mass $m_p = 1836m_e$ are moving with the same speed. The ratio of their de-Broglie wavelength $\frac{\lambda_{electron}}{\lambda_{proton}}$ will be [25 Feb 2021 Shift 2]

Options:

A. 1

B. 1836

C. $\frac{1}{1836}$

D. 918

Answer: B

Solution:

Given, mass of proton (m_p) is 1836 times the mass of electron (m_e) and velocity of proton (v_p) is equal to velocity of electron (v_e).

As, wavelength (λ) = $\frac{h}{p} = \frac{h}{mv}$

where, h is Planck's constant and p is momentum. $\therefore\ \lambda \propto \frac{1}{m}$

$\Rightarrow\ \frac{\lambda_e}{\lambda_\rho} = \frac{m_p}{m_e} = \frac{1836m_e}{m_e} = 1836$

Question59

A proton, a deuteron and an α-particle are moving with same momentum in a uniform magnetic field. The ratio of magnetic forces acting on them is .... and their speed is .... in the ratio. [25 Feb 2021 Shift 1]

Options:

A. 1 : 2 : 4 and 2 : 1 : 1

B. 2 : 1 : 1 and 4 : 2 : 1

C. 4 : 2 : 1 and 2 : 1 : 1

D. 1 : 2 : 4 and 1 : 1 : 2

Answer: B

Solution:

Let F_p, F_d and F_α be the forces and v_p, v_d and v_α be the velocities of proton, deuteron and α−particle, respectively.

Since, $F = Bqv$

On dividing and multiplying F by m, we get

$F = Bqv\frac{m}{m}$

$\Rightarrow\ F = B\frac{q}{m}p$ ($\because p = mv$)

$\Rightarrow\ F \propto q / m$ ($\because$p and B are same)

$\therefore\ F_p : F_d : F_\alpha = \frac{+q}{m} : \frac{+q}{2m} : \frac{+2q}{4m}$

$= 1 : 1/2 : 1/2 = 2 : 1 : 1$

and $= Bqv$

$\Rightarrow\ \propto F / q$

$\therefore\ v_p : v_d : v_\alpha = \frac{F_p}{q_p} : \frac{F_d}{q_d} : \frac{F_\alpha}{q_\alpha} = \frac{2x}{q} : \frac{x}{q} : \frac{x}{2q}$

$= 2 : 1 : 1/2 = 4 : 2 : 1$

Question60

The de-Broglie wavelength of a proton and α-particle are equal. The ratio of their velocities is [24 Feb 2021 Shift 2]

Options:

A. 4 : 3

B. 4 : 1

C. 4 : 2

D. 1: 4

Answer: B

Solution:

Solution:
Let λ_p, λ_α, m_p, m_α, v_p, v_α, p_p and p_α be the wavelength, mass, velocity and momentum of proton and α-particle, respectively.
Given, $\lambda_p = \lambda_\alpha$
As we know that,
$\lambda = h / p$
$$\frac{h}{p_p} = \frac{h}{p_\alpha}$$
$$\therefore p_p = p_\alpha$$
$$\Rightarrow m_p v_p = m_\alpha v_\alpha$$
$$\Rightarrow m_p v_p = 4 m_p v_\alpha$$
$$\Rightarrow \frac{v_p}{v_\alpha} = \frac{4}{1} \text{ or } 4 : 1$$

Question61

An X-ray tube is operated at 1.24 million volt. The shortest wavelength of the produced photon will be [24 Feb 2021 Shift 2]

Options:

A. 10^{-3}nm

B. 10^{-1}nm

C. 10^{-2}nm

D. 10^{-4}nm

Answer: A

Solution:

Given, $V = 1.24$ million volt $= 1.24 \times 10^{6}$ volt
Since, energy $(E) = eV$
where, e is the charge of electron $= 1.6 \times 10^{-19} C$
$\therefore\ E = 1.6 \times 10^{-19} \times 1.24 \times 10^{6}$ ... (i)
As we know that,
Energy of photon, $E = \frac{hc}{\lambda}$ ...(ii)
Here, Planck's constant, $h = 6.67 \times 10^{-34} J - s$,
$C =$ speed of light in free space, $C = 3 \times 10^{8} ms^{-1}$
Equating Eqs. (i) and (ii), we get
$1.6 \times 10^{-19} \times 1.24 \times 10^{6} = \frac{6.67 \times 10^{-34} \times 3 \times 10^{8}}{\lambda}$
$\Rightarrow \lambda = \frac{20.01 \times 10^{-13}}{1.6 \times 1.24} = 10.09 \times 10^{-13}$
$= 1.009 \times 10^{-12} \sim eq 10^{-3} \times 10^{-9}$
$= 10^{-3} nm$

Question62

Given below are two statements :
Statement-I : Two photons having equal linear momenta have equal wavelengths.
Statement-II: If the wavelength of photon is decreased, then the momentum and energy of a photon will also decrease.
In the light of the above statements, choose the correct answer from the options given below.
[24feb2021shift1]

Options:

A. Both Statement I and Statement II are true

B. Statement I is false but Statement II is true

C. Both Statement I and Statement II are false

D. Statement I is true but Statement II is false

Answer: D

Solution:

Solution:
Momentum of photon,
$p = \frac{h}{\lambda}$
Here, $h =$ Plank's constant,
$\lambda =$ wavelength of light
Energy of photon $E = \frac{hc}{\lambda}$
If linear momentum are equal then wavelength also equal.
On decreasing wavelength, momentum and energy of photon increases.

Question63

Two identical photocathodes receive the light of frequencies f_1 and f_2, respectively. If the velocities of the photoelectrons coming out are v_1 and v_2 respectively, then
[17 Mar 2021 Shift 2]

Options:

A. $v_1^2 - v_2^2 = \frac{2h}{m}[f_1 - f_2]$

B. $v_1^2 + v_2^2 = \frac{2h}{m}[f_1 + f_2]$

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

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

Answer: A

Solution:

Solution:
We know that, the photoelectric effect equation,
$KE = hf - \varphi$
Here, $KE =$ kinetic energy of the electrons
$h =$ Planck's constant
$f =$ frequency of the light and
$\varphi =$ work-function of the photocathodes.
For two identical photocathodes,
$\frac{1}{2}mv_1^2 = hf_1 - \varphi$....(i)
$\frac{1}{2}mv_2^2 = hf_2 - \varphi$.....(ii)
Since, the material of photocathodes is same, so the value of the work-function φ is same.
Subtracting Eq. (ii) from Eq. (i) we get
$\frac{1}{2}mv_1^2 - \frac{1}{2}mv_2^2 = hf_1 - hf_2$
$v_1^2 - v_2^2 = \frac{2h}{m}(f_1 - f_2)$

Question64

The stopping potential in the context of photoelectric effect depends on the following property of incident electromagnetic radiation
[16 Mar 2021 Shift 1]

Options:

A. phase

B. intensity

C. amplitude

D. frequency

Answer: D

Solution:

Solution:
The stopping potential V_0 is related to the frequency of incident radiations by following relation
$eV_0 = h\nu - \varphi$ ($\varphi =$ work-function)
The stopping potential in the context of photoelectric effect depends only on the frequency ν of incident electromagnetic radiation.

Question65

If $2.5 \times 10^{-6} N$ average force is exerted by a light wave on a non-reflecting surface of $30 cm^2$ area during 40 min of time span, the energy flux of light just before it falls on the surface is ......W \/ cm^2.
(Round off to the nearest integer. Assume complete absorption and normal incidence conditions are there.)
[17 Mar 2021 Shift 1]

Answer: 25

Solution:

Given, average force, $F = 2.5 \times 10^{-6} N$
Area, $A = 30 cm^2$
Time, $t = 40 min$
We know that, $F = \frac{IA}{c}$
where, $I =$ energy flux of light
and $c =$ speed of light in air.
$\Rightarrow I = \frac{FC}{A} = \frac{2.5 \times 10^{-6} \times 3 \times 10^8}{30} = 25 W/cm^2$

Question66

The speed of electrons in a scanning electron microscope is $1 \times 10^7 ms^{-1}$. If the protons having the same speed are used instead of electrons, then the resolving power of scanning proton microscope will be changed by a factor of
[18 Mar 2021 Shift 2]

Options:

A. 1837

B. $\frac{1}{1837}$

C. $\sqrt{1837}$

D. $\frac{1}{\sqrt{1837}}$

Answer: A

Solution:

According to de-Broglie wavelength,

$\lambda = \frac{h}{mv}$ Since, resolving power,

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

$\Rightarrow RP \propto \frac{mv}{h}$

$\Rightarrow RP \propto m$ (speed = constant)

$\Rightarrow \frac{RP_p}{RP_e} = \frac{m_p}{m_e}$

$\Rightarrow \frac{RP_p}{RP_e} = 1837$ (given, $m_\rho = 1837 m_e$)

Hence, the resolving power of scanning proton microscope will be changed by factor of 1837.

Question67

A particle is travelling 4 times as fast as an electron. Assuming the ratio of de-Broglie wavelength of a particle to that of electron is 2 : 1, the mass of the particle is
[18 Mar 2021 Shift 1]

Options:

A. $\frac{1}{16}$ times the mass of electron

B. 8 times the mass of electron

C. 16 times the mass of electron

D. $\frac{1}{8}$ times the mass of electron

Answer: D

Solution:

Solution:

Given, $\frac{\lambda_p}{\lambda_e} = \frac{2}{1}, \frac{v_e}{v_p} = \frac{1}{4}$

We know that, de-Broglie wavelength,

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

$\Rightarrow \frac{\lambda_p}{\lambda_e} = \frac{m_e v_e}{m_p v_p} \Rightarrow \frac{2}{1} = \frac{m_e}{m_p}\left(\frac{1}{4}\right)$

$\Rightarrow m_p = \frac{1}{8} m_e$

Question68

An electron of mass m and a photon have same energy E . The ratio of wavelength of electron to that of photon is (c being the velocity of light) [17 Mar 2021 Shift 1]

Options:

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

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

C. $\left(\frac{E}{2m}\right)^{1/2}$

D. $c(2mE)^{1/2}$

Answer: B

Solution:

Solution:
We know
$\lambda = \frac{h}{p}$...(i)
where, $\lambda =$ wavelength,
$h =$ Planck's constant
and $p =$ linear momentum
AlsO, kinetic energy $(KE) = \frac{1}{2}mv^2 = \frac{p^2}{2m}$
$\Rightarrow p = \sqrt{2mKE}$ ...(ii)
From Eqs. (i) and (ii), we get
$\lambda = \frac{h}{\sqrt{2mKE}}$ or $\lambda = \frac{h}{\sqrt{2mE}}$ $[\because KE = E]$
Wavelength of electron, $\lambda_e = \frac{h}{\sqrt{2mE}}$
and wavelength of photon, $\lambda_p = \frac{hc}{E}$
[∵ Both electron and photon have same energy.]
$\Rightarrow \frac{\lambda_e}{\lambda_p} = \frac{\frac{h}{\sqrt{2mE}}}{\frac{hc}{E}} \Rightarrow \frac{\lambda_e}{\lambda_p} = \frac{1}{c}\left(\frac{E}{2m}\right)^{1/2}$

Question69

The de-Broglie wavelength associated with an electron and a proton were calculated by accelerating them through same potential of 100V . What should nearly be the ratio of their wavelengths? ($m_p = 1.00727u$, $m_e = 0.00055u$) [16 Mar 2021 Shift 2]

Options:

A. 1860 : 1

B. $(1860)^2 : 1$

C. 41.4 : 1

D. 43 : 1

Answer: D

Solution:

Solution:
Given, mass of proton, $m_p = 1.00727u$
Mass of electron, $m_e = 0.00055u$
Potential, $V = 100V$
As, de-Broglie wavelength can be given as

$$\lambda = \frac{h}{\sqrt{2mqV}} \Rightarrow \lambda \propto \frac{1}{\sqrt{m}}$$

$$\Rightarrow \frac{\lambda_1}{\lambda_2} = \sqrt{\frac{m_2}{m_1}}$$

$$\Rightarrow \frac{\lambda_e}{\lambda_p} = \sqrt{\frac{m_p}{m_e}} = \sqrt{\frac{1.00727u}{0.00055u}}$$

$$\frac{\lambda_e}{\lambda_p} = \sqrt{1831.4} = 42.79$$

or $\frac{\lambda_e}{\lambda_p} \approx \frac{43}{1}$ or $\lambda_e : \lambda_p = 43 : 1$

Question70

A light beam of wavelength 500nm is incident on a metal having work function of 1.25eV, placed in a magnetic field of intensity B. The electrons emitted perpendicular to the magnetic field B, with maximum kinetic energy are bent into circular arc of radius 30cm. The value of B is _______ $\times 10^{-7}$T
Given $hc = 20 \times 10^{-26}$J − m, mass of electron = 9×10^{-31}kg
[25 Jul 2021 Shift 2]

Answer: 125

Solution:

By photoelectric equation

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

$$k_{max} = \frac{1240}{500} - 1.25 \approx 1.25$$

$$r = \frac{\sqrt{2mk}}{eB}$$

$$B = \frac{\sqrt{2mk}}{er}$$

$= 125 \times 10^{-7} T$

Question71

When radiation of wavelength λ is incident on a metallic surface, the stopping potential of ejected photoelectrons is 4.8V . If the same surface is illuminated by radiation of double the previous wavelength, then the stopping potential becomes 1.6V . The threshold wavelength of the metal is :
[25 Jul 2021 Shift 2]

Options:

A. 2λ

B. 4λ

C. 8λ

D. 6λ

Answer: B

Solution:

Solution:
$V_s = hv - \phi$
$4.8 = \frac{hc}{\lambda} - \phi$ ....(i)
$1.6 = \frac{hc}{2\lambda} - \phi$ ....(ii)
Using above equation (i) - (ii)
$3.2 = \frac{hc}{\lambda} - \frac{hc}{2\lambda}$
$3.2 = \frac{hc}{2\lambda}$ ....(iii)
$\left[\lambda = \frac{hc}{6.4} \right]$
Put in equation (ii)
$\phi = 1.6$
$\frac{hc}{\lambda_{th}} = 1.6$
$\lambda_{th} = \frac{hc}{1.6}$
$= \left(\frac{hc}{6.4} \right) \times 4 = 4\lambda$

Question72

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

[20 Jul 2021 Shift 2]

Answer: 4

Solution:

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

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

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

Using (i) & (ii)

$\phi = \frac{hc}{4\lambda_0} = \frac{hc}{\lambda_t}$

$\lambda_t = 4\lambda_0$

Question73

A particle of mass 9.1×10^{-31}kg travels in a medium with a speed of 10^6m / s and a photon of aradiation of linear momentum 10^{-27}kgm / s travelsin vacuum. The wavelength of photon is _______ times the wavelength of the particle.
[27 Jul 2021 Shift 1]

Answer: 910

Solution:

For photon $\lambda_1 = \frac{h}{P} = \frac{6.6 \times 10^{-34}}{10^{-27}}$

For particle $\lambda_2 = \frac{h}{mv} = \frac{6.6 \times 10^{-34}}{9.1 \times 10^{-31} \times 10^6}$

$\therefore \frac{\lambda_1}{\lambda_2} = 910$

Question74

An electron moving with speed v and a photon moving with speed c, have same D-Broglie wavelength. The ratio of kinetic energy of electron to that of photon is :
[25 Jul 2021 Shift 2]

Options:

A. $\frac{3c}{v}$

B. $\frac{v}{3c}$

C. $\frac{v}{2c}$

D. $\frac{2c}{v}$

Answer: C

Solution:

$\lambda_e = \lambda_{Ph}$

$\frac{h}{p_e} = \frac{h}{p_{ph}}$

$\sqrt{2mk_e} = \frac{E_{ph}}{c}$

$2mk_e = \frac{(E_{ph})^2}{c^2}$

$\frac{k_e}{E_{ph}} = \frac{E_{ph}}{c^2}\left(\frac{1}{2m}\right)$

$= \frac{p_{ph}}{c}\left(\frac{1}{2m}\right)$

$= \frac{p_e}{c}\left(\frac{1}{2m}\right)$

$= \frac{mv}{c}\frac{1}{2m}$

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

Question75

An electron of mass m_e and a proton of mass m_P are accelerated through the same potential difference. The ratio of the de-Broglie wavelength associated with the electron to that with the proton is :- [22 Jul 2021 Shift 2]

Options:

A. $\frac{m_p}{m_e}$

B. 1

C. $\sqrt{\frac{m_p}{m_e}}$

D. $\frac{m_e}{m_p}$

Answer: C

Solution:

Solution:
$KE = e\Delta V$

$\lambda_e = \frac{h}{\sqrt{2m_e(e\Delta V)}}$

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

$\Rightarrow \frac{\lambda_e}{\lambda_P} = \sqrt{\frac{m_p}{m_e}}$

Question76

An electron having de-Broglie wavelength λ is incident on a target in a X-ray tube. Cut-off wavelength of emitted X-ray is : [20 Jul 2021 Shift 2]

Options:

A. 0

B. $\frac{2m^2c^2\lambda^2}{h^2}$

C. $\frac{2mc\lambda^2}{h}$

D. $\frac{hc}{mc}$

Answer: C

Solution:

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

kinetic energy, $\frac{P^2}{2m} = \frac{h^2}{2m\lambda^2} = \frac{hc}{\lambda_c}$

$\lambda_c = \frac{2m\lambda^2 c}{h}$

Question77

In a photoelectric experiment, increasing the intensity of incident light [27 Aug 2021 Shift 1]

Options:

A. increases the number of photons incident and also increases the KE of the ejected electrons.

B. increases the frequency of photons incident and increases the KE of the ejected electrons.

C. increases the frequency of photons incident and the KE of the ejected electrons remains unchange

D. d. increases the number of photons incident and the KE of the ejected electrons remains unchanged.

Answer: D

Solution:

Solution:
As per Einstein's theory of photoelectric effect when a photon strikes the metal surface it ejects an electron. If we increase the intensity of light, the number of photons incident on surface will increase and thus, the number of electrons ejected willincrease proportionally and the photocurrent will also increase. Kinetic energy of ejected electrons is given as
$\frac{1}{2}m_e v_e^2 = eV_0$
Here, V_0 is stopping potential.
The stopping potential of surface is constant and it will not increase with increase in intensity of light, so the kinetic energy of ejected electrons will not increase.
Thus, increasing the intensity of light will increase the number of photons incident and the kinetic energy will remain unchanged.

Question78

A monochromatic neon lamp with wavelength of 670.5 nm illuminates a photo-sensitive material which has a stopping voltage of 0.48V. What will be the stopping voltage if the source light is changed with another source of wavelength of 474.6 nm ?
[27 Aug 2021 Shift 2]

Options:

A. 0.96 V

B. 1.25 V

C. 0.24 V

D. 1.5 V

Answer: B

Solution:

Solution:
In, case I given, incident wavelength,
$\lambda_1 = 670.5\text{nm}$
Stopping potential, $V_1 = 0.48\text{V}$
In case II Incident wavelength,
$\lambda_2 = 474.6\text{nm}$
Stopping potential is V_2 .
By using Einstein photoelectric
equation, $eV_1 = \frac{hc}{\lambda_1} - \varphi_0$
where, h is Planck's constant
$= 6.63 \times 10^{-34}\text{J s}$
c is speed of light $= 3 \times 10^8 \text{ms}^{-1}$
φ_0 is work function

$\therefore\ eV_1 = \frac{hc}{\lambda_1} - \varphi_0$

and similarly, $eV_2 = \frac{hc}{\lambda_2} - \varphi_0$

$\Rightarrow\ \varphi_0 = \frac{hc}{\lambda_2} - eV_2$

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

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

$\Rightarrow eV_1 - eV_2 = hc\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right)$

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

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

$= 0.48 + \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{1.6 \times 10^{-19}}$

$= \left(\frac{1}{474.6} - \frac{1}{670.5}\right)$

$= 0.48 + 12.4 \times 10^{-7+9}(2.11 \times 10^{-3} - 1.49 \times 10^{-3})$

$= 0.48 + 12.4 \times 10^{2-3} \times 0.62$

$= 0.48 + 0.77 = 1.25V$

Question79

In a photoelectric experiment ultraviolet light of wavelength 280 nm is used with lithium cathode having work - function $\phi = 2.5$ eV. If the wavelength of incident light is switched to 400 nm, find out the change in the stopping potential. ($h = 6.63 \times 10^{-34}$ Js., and $c = 3 \times 10^{8} ms^{-1}$) [26 Aug 2021 Shift 1]

Options:

A. 1.3V

B. 1.1V

C. 1.9V

D. 0.6V

Answer: A

Solution:

Solution:

By Einstein's photoelectric equation, we have

$\Rightarrow hf = \phi + (KE)_{max}$

where, f is the frequency, ϕ is the work-function of metal and $(KE)_{max}$ is the maximum kinetic energy of emitted photoelectron.

$\Rightarrow \frac{hc}{\lambda} = \phi + eV_0$

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

Here, $\lambda = 280$ nm and $\phi = 2.5$ eV

$\Rightarrow e(V_0)_1 = \frac{1240}{280} - 2.5$

$\Rightarrow e(V_0)_1 = 1.93$ eV

$\Rightarrow (V_0)_1 = 1.93V$

Similarly, stopping potential for the light of wavelength of 400 nm,

$e(V_0)_2 = \frac{1240}{400} - 2.5$
$\Rightarrow (V_0)_2 = 0.6V$
∴ Change in stopping potential,
$\Delta V = (V_0)_1 - (V_0)_2$
$= 1.93 - 0.6 = 1.33 \simeq 1.3V$

Question80

Consider two separate ideal gases of electrons and protons having same number of particles. The temperature of both the gases are same. The ratio of the uncertainty in determining the position of an electron to that of a proton is proportional to [31 Aug 2021 Shift 2]

Options:

A. $\left(\frac{m_p}{m_e}\right)^{\frac{3}{2}}$

B. $\sqrt{\frac{m_e}{m_p}}$

C. $\sqrt{\frac{m_p}{m_e}}$

D. $\frac{m_p}{m_e}$

Answer: C

Solution:

Solution:
At same temperature kinetic energy of proton and electron are same
$KE_p = KE_e$
$\Rightarrow \frac{p_p^2}{2m_p} = \frac{p_e^2}{2m_e}$
$\frac{p_p^2}{p_e^2} = \frac{m_p}{m_e}$ ...(i)
Using uncertainty in determining the position, $\Delta x \approx \frac{h}{\Delta p}$
Ratio,∴ $\frac{\Delta x_e}{\Delta x_p} = \frac{\Delta p_p}{\Delta p_e} = \sqrt{\frac{m_p}{m_e}}$ [from Eq. (i)]

Question81

A moving proton and electron have the same de-Broglie wavelength. If k and p denote the KE and momentum, respectively. Then, choose the correct option. [31 Aug 2021 Shift 1]

Options:

A. $K_p < K_e$ and $p_p = p_e$

B. $K_p = K_e$ and $p_p = p_e$

C. $K_p < K_e$ and $p_p < p_e$

D. $K_p > K_e$ and $p_p = p_e$

Answer: A

Solution:

Solution:
Let de-Broglie wavelength of proton and electron are λ_p and λ_e.
Kinetic energy of electron and proton are K_e and K_p.
Momentum of electron and proton are p_e and p_P.
According to question, $\lambda_p = \lambda_e = \lambda$
By using de-Broglie wavelength,
$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2\,mK}}$
where, m is mass and h is Planck's constant.
$\therefore p = \frac{h}{\lambda}$ ...(i)
From Eq. (i)
$p_e = p_p$ as $\lambda_e = \lambda_p$
Again, $K = \frac{h^2}{2m\lambda}$ ...(ii)
From Eq. (ii)
$\therefore \frac{K_e}{K_p} = \frac{m_p}{m_e} \times \frac{\lambda_p}{\lambda_e}$
$\Rightarrow \frac{K_e}{K_p} = \frac{m_p}{m_e}$ $[\because \lambda_e = \lambda_p]$
$\because m_p > m_e$
$K_e > K_p$

Question82

The de-Broglie wavelength of a particle having kinetic energy E is λ. How much extra energy must be given to this particle, so that the de-Broglie wavelength reduces to 75% of the initial value ? [26 Aug 2021 Shift 2]

Options:

A. $\frac{1}{9}E$

B. $\frac{7}{9}E$

C. E

D. $\frac{16}{9}E$

Answer: B

Solution:

Solution:
Given, initial kinetic energy, $E_1 = E$
Initial de-Broglie wavelength, $\lambda_1 = \lambda$
Consider the wavelength of particle changes to 75% of λ after providing energy ΔE to the particle.
Hence, final wavelength of particle, $\lambda_2 = 0.75\lambda$
Final energy, $E_2 = E + \Delta E$
Relationship between de-Broglie wavelength and energy of particleis given as
$\lambda = \frac{h}{\sqrt{2mE}}$
Here, h is Planck's constant and m is mass of particle which is alsoconstant term.
Therefore, we get
$\lambda \propto \frac{1}{\sqrt{E}}$
Thus, we can write the relationship as
$\frac{\lambda_1}{\lambda_2} = \frac{\sqrt{E_2}}{\sqrt{E_1}}$
$\Rightarrow \frac{\lambda}{0.75\lambda} = \frac{\sqrt{E + \Delta E}}{\sqrt{E}}$
$\Rightarrow \frac{4}{3} = \frac{\sqrt{E + \Delta E}}{\sqrt{E}}$
Squaring both sides of above equation, we get
$\Rightarrow \frac{16}{9} = \frac{E + \Delta E}{E}$
$\Rightarrow 16E = 9E + 9\Delta E$
$\Delta E = \frac{7}{9}E$

Question83

The temperature of an ideal gas in 3 - dimensions is 300K. The corresponding de-Broglie wavelength of the electron approximately at 300K, is
[m_e = mass of electron = 9×10^{-31} kg
h = Planck's constant = 6.6×10^{-34} Js
K_B = Boltzmann constant = $1.38 \times 10^{-23} JK^{-1}$]
[1 Sep 2021 Shift 2]

Options:

A. 6.26 nm

B. 8.46 nm

C. 2.26 nm

D. 3.25 nm

Answer: A

Solution:

Solution:
Given, Planck's constant, $h = 6.6 \times 10^{-34}$ Js

Boltzmann constant, $k_B = 1.38 \times 10^{-23} J / K$
Mass of an electron, $m_e = 9 \times 10^{-31}$ kg
Temperature of an ideal gas, $T = 300K$
As we know that, de-Broglie wavelength,
$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2\,mE}}$ ... (i)
Here, E is the kinetic energy.
$E = \frac{3K_B T}{2}$
Substituting value of E in Eq. (i), we get,
$\lambda = \frac{h}{\sqrt{3mK_B T}}$
Substituting the given values in the above equation, we get
$\lambda = \frac{6.6 \times 10^{-34}}{\sqrt{3 \times 9 \times 10^{-31} \times 138 \times 10^{-23} \times 300}}$
= 6.26 nm
∴ The corresponding de-Broglie wavelength of an electronapproximately at 300 K is 6.26 nm.

Question84

A particle moving with kinetic energy E has de Broglie wavelength λ. If energy ΔE is added to its energy, the wavelength become $\frac{\lambda}{2}$. Value of ΔE , is:
[9 Jan. 2020 I]

Options:

A. E

B. 4E

C. 3E

D. 2E

Answer: C

Solution:

Solution:
As per question, when KE of particle E, wavelength λ and when KE becomes $E + \Delta E$ wavelength becomes $\lambda / 2$
Using, $\lambda = \frac{h}{\sqrt{2mKE}}$
$\frac{\lambda}{2} = \frac{h}{\sqrt{2m(KE + \Delta E)}}$
$\Rightarrow \frac{\lambda}{\lambda / 2} = \sqrt{\frac{KE + \Delta E}{KE}}$
$\Rightarrow 4 = \frac{KE + \Delta E}{KE}$
$\Rightarrow 4KE - KE = \Delta E$
$\therefore \Delta E = 3KE = 3E$

Question85

An electron of mass m and magnitude of charge |e| initially at rest gets accelerated by a constant electric field E . The rate of change of de-

Broglie wavelength of this electron at time t ignoring relativistic effects is:
[9 Jan. 2020 II]

Options:

A. $-\frac{h}{|e|E\sqrt{t}}$

B. $\frac{|e|E\,t}{h}$

C. $-\frac{h}{|e|E\,t}$

D. $\frac{-h}{|e|E\,t^2}$

Answer: D

Solution:

Solution:

Acceleration of electron in electric field, $a = \frac{eE}{m}$

Using equation

$v = u + at$

$\Rightarrow v = 0 + \frac{eE}{m}t$

$\Rightarrow v = \frac{eE\,t}{m}$ ....(i)

De-broglie wavelength λ is given by

$\lambda = \frac{h}{mv} = \frac{h}{m\left(\frac{eE\,t}{m}\right)}$ [using (i)]

$\Rightarrow \lambda = \frac{h}{eE\,t}$

Differentiating w.r.t.

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

Question86

An electron (mass m) with initial velocity $\vec{v} = v_0\hat{i} + v_0\hat{j}$ is in an electric field $\vec{E} = -E_0\hat{k}$. If λ_0 is initial de-Broglie wavelength of electron, its de-Broglie wave length at time t is given by:
[8 Jan. 2020 II]

Options:

A. $\frac{\lambda_0\sqrt{2}}{\sqrt{1 + \frac{e^2E^2t^2}{m^2v_0^2}}}$

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

C. $\frac{\lambda_0}{\sqrt{1+\frac{e^2E^2t^2}{2m^2v_0^2}}}$

D. $\frac{\lambda_0}{\sqrt{2+\frac{e^2E^2t^2}{m^2v_0^2}}}$

Answer: C

Solution:

Solution:

Given, Initial velocity, $u = v_0\hat{i} + v_0\hat{j}$

Acceleration, $a = \frac{qE_0}{m} = \frac{eE_0}{m}$

Using $v = u + at$

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

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

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

$\Rightarrow \lambda = \frac{h}{mv}(\because p = mv)$

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

Final wavelength,

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

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

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

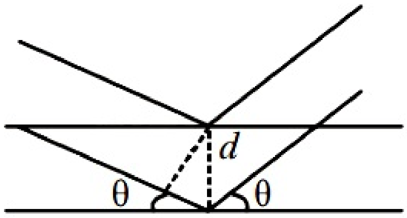
Question87

A beam of electrons of energy E scatters from a target having atomic spacing of 1Å. The first maximum intensity occurs at θ = 60°. Then E (in eV) is ______.
(Plank constant $h = 6.64 \times 10^{-34}$ J s, $1eV = 1.6 \times 10^{-19}$ J, electron mass $m = 9.1 \times 10^{-31}$ kg)
[NA Sep. 05, 2020 (I)]

Answer: 50

Solution:

From Bragg's equation $2d\ \sin\theta = \lambda$ and de-Broglie wavelength, $\lambda = \frac{h}{P} = \frac{h}{\sqrt{2mE}}$



$2d\ \sin\theta = \lambda = \frac{h}{\sqrt{2mE}}$

$\Rightarrow 2 \times 10^{-10} \times \frac{\sqrt{3}}{2} = \frac{6.6 \times 10^{-34}}{\sqrt{2mE}}$

[$\because ^{\circ} = 60^{\circ}$ and $d\ = 1\text{Å} = 1 \times 10^{-10}\text{m}$]

$\therefore E\ = \frac{1}{2} \times 6.64^2 \times \frac{10^{-48}}{9.1 \times 10^{-31} \times 3 \times 1.6 \times 10^{-19}} \simeq 50\text{eV}$

Question88

Radiation, with wavelength 6561 Å falls on a metal surface to produce photoelectrons. The electrons are made to enter a uniform magnetic field of 3×10^{-4} T. If the radius of the largest circular path followed by the electrons is 10 mm, the work function of the metal is close to: [9 Jan. 2020 I]

Options:

A. 1.1 ev

B. 0.8 ev

C. 1.6 ev

D. 1.8 ev

Answer: A

Solution:

Solution:
Using Einstein's photoelectric equation,

$E\ = \omega_0 + KE_{max}$

$\Rightarrow \omega_0 = KE_{max} - E$

$p = \sqrt{2mKE} \Rightarrow KE\ = \frac{p^2}{2m}$

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

$K_{max} = \frac{r^2e^2B^2}{2m}\ KE_{max} = \frac{12420}{\lambda} - \omega_0$

$\Rightarrow \omega_0 = \frac{12420}{6561} - \frac{r^2eB^2}{2m}(\text{I neV})$

$= 1.89(\text{eV}) - \frac{(10^{-4})(1.6 \times 10^{-19})9 \times 10^5}{2 \times 9.07 \times 10^{-31}}$

$= 1.89(\text{eV}) - \frac{(10^{-4})(1.6 \times 10^{-19})9 \times 10^5}{2 \times 9.07 \times 10^{-31}}$

$= (1.89 - 0.79)\text{eV}\ = 1.1\text{eV}$

Question89

When photon of energy 4.0eV strikes the surface of a metal A, the ejected photoelectrons have maximum kinetic energy T_AeV and de-Broglie wavelength λ_A. The maximum kinetic energy of photoelectrons liberated from another metal B by photon of energy 4.50eV is $T_B = (T_A - 1.5)$eV. If the de-Broglie wavelength of these photoelectrons $\lambda_B = 2\lambda_A$, then the work function of metal B is:
[8 Jan. 2020 I]

Options:

A. 4 eV

B. 2 eV

C. 1.5 eV

D. 3 eV

Answer: A

Solution:

Solution:
de-Broglie wavelength (λ),
Momentum, $mv = \frac{h}{\lambda} = p = \sqrt{2m(KE)}$
$\therefore \lambda = \frac{h}{\sqrt{2mKE}} \Rightarrow \lambda \propto \frac{1}{\sqrt{KE}}$
$\therefore \frac{\lambda_A}{\lambda_B} = \sqrt{\frac{K_B}{K_A}} = \sqrt{\frac{T_A - 1.5}{T_A}}$ (as given)
Also, $\frac{\lambda_A}{\lambda_B} = \frac{1}{2}$
On solving we get, $T_A = 2eV$
$\therefore KE_B = T_A - 1.5 = 2 - 1.5 = 0.5eV$
$\therefore$ Work function of metal B is
$\phi_B = E_B - KE_B = 4.5 - 0.5 = 4eV$

Question90

A beam of electromagnetic radiation of intensity $6.4 \times 10^{-5} W/cm^2$ is comprised of wavelength, λ = 310 nm. It falls normally on a metal (work function $\varphi = 2eV$) of surface area of $1 cm^2$. If one in 10^3 photons ejects an electron, total number of electrons ejected in 1s is 10^x.
($hc = 1240 eV\,nm$, $1eV = 1.6 \times 10^{-19} J$), then x is ______.
[NA 7 Jan. 2020 I]

Answer: 11

Solution:

Energy of proton

$E = \frac{hc}{\lambda} = \frac{1240}{310} = 4eV > 2eV\,[s\phi]$

(so emission of photoelectron will take place)

$= 4 \times 1.6 \times 10^{-19} = 6.4 \times 10^{-19}$ joule

$N = \frac{6.4 \times 10^{-5} \times 1}{4 \times 6.4 \times 10^{-19}} = 10^{14}$

No. of photoelectrons emitted per second $= \frac{10^{14}}{10^{3}} = 10^{11}$ ($\because 1$ in 10^{3} photons ejects an electron)

$\therefore$ Value of $X = 11.00$

Question91

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

[Sep. 06, 2020 (I)]

Options:

A. $\lambda_e > \lambda_{He++} > \lambda_p$

B. $\lambda_e < \lambda_{He++} = \lambda_p$

C. $\lambda_e > \lambda_p > \lambda_{He++}$

D. $\lambda_e < \lambda_p < \lambda_{He++}$

Answer: C

Solution:

de-Broglie wavelength, $\lambda = \frac{h}{P} = \frac{h}{\sqrt{2m(KE)}}$

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

As $m_{He^{+}} > m_P > m_e$

$\lambda_{He^{++}} > \lambda_P > \lambda_e$ or $\lambda_e > \lambda_P > \lambda_{He^{++}}$

Question92

Assuming the nitrogen molecule is moving with r.m.s.velocity at 400 K, the de-Broglie wavelength of nitrongen molecule is close to :
(Given : nitrogen molecule weight : 4.64×10^{-26} kg, Boltzman constant : 1.38×10^{-23} J/K, Planck constant : 6.63×10^{-34} J.s)

[Sep. 06, 2020 (II)]

Options:

A. 0.24 Å

B. 0.20 Å

C. 0.34 Å

D. 0.44 Å

Answer: A

Solution:

Rms speed of gas molecule, $V_{rms} = \sqrt{\frac{3kT}{m}}$

de Broglie wavelength, $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mk}}$

$\therefore \lambda = \frac{h}{\sqrt{2m \times \frac{1}{2}mV_{rms}^2}} = \frac{h}{\sqrt{m \times \frac{3}{2}kT}} = \frac{h}{\sqrt{3mkT}}$

Substituting the respective values we get

$\lambda = \frac{6.63 \times 10^{-34}}{\sqrt{3 \times 4.64 \times 10^{-26} \times 1.38 \times 10^{-13} \times 400}} = 0.24Å$

Question93

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

[Sep. 04, 2020 (I)]

Options:

A. $\Delta\lambda = \frac{3}{2}\lambda_0$

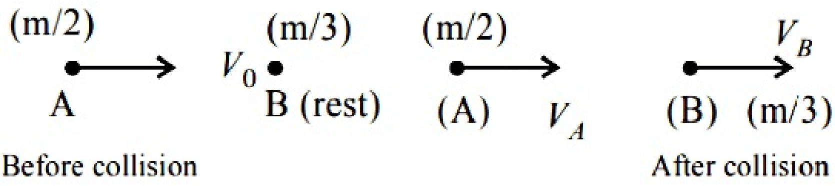
B. $\Delta\lambda = \frac{5}{2}\lambda_0$

C. $\Delta\lambda = 2\lambda_0$

D. $\Delta\lambda = 4\lambda_0$

Answer: D

Solution:



Applying momentum conservation

$\frac{m}{2} \times V_0 + \frac{m}{3} \times (0) = \frac{m}{2} V_A + \frac{m}{3} V_B$

$= \frac{V_0}{2} = \frac{V_A}{2} + \frac{V_B}{3}$ .....(i)

Since, collision is elastic

$e = 1 = \frac{V_B - V_A}{V_0} \Rightarrow V_0 = V_B - V_A$ ....(ii)

On solving equations (i) and (ii) : $V_A = \frac{V_0}{5}$

Now, de-Broglie wavelength of A before collision :

$\lambda)_0 = \frac{h}{m_A V_0} = \frac{h}{\left(\frac{m}{2}\right) V_0} \Rightarrow \lambda_0 = \frac{2h}{mV_0}$

Final de-Broglie wavelength :

$\lambda_f = \frac{h}{m_A V_0} = \frac{h}{\frac{m}{2} \times \frac{V_0}{5}} \Rightarrow \lambda_f = \frac{10h}{mV_0}$

$\therefore \Delta\lambda = \lambda_f - \lambda_0 = \frac{10h}{mV_0} - \frac{2h}{mV_0}$

$\Rightarrow \Delta\lambda = \frac{8h}{mv_0} \Rightarrow \Delta\lambda = 4 \times \frac{2h}{mv_0}$

$\therefore \Delta\lambda = 4\lambda_0$

Question94

A particle is moving 5 times as fast as an electron. The ratio of the de-Broglie wavelength of the particle to that of the electron is 1.878×10^{-4}. The mass of the particle is close to : [Sep. 02, 2020 (II)]

Options:

A. 4.8×10^{-27}kg

B. 9.1×10^{-31}kg

C. 1.2×10^{-28}kg

D. 9.7×10^{-28}kg

Answer: D

Solution:

Solution:

de Broglie wavelength

$\lambda = \frac{h}{mv} \Rightarrow m = \frac{h}{\lambda v}$

Clearly, $m \propto \frac{1}{\lambda v}$

If λ and v be the wavelength and velocity of electron and χ' and v' be the wavelength and velocity of the particle then

$\Rightarrow \frac{m'}{m} = \frac{v\lambda}{v'\lambda'} = \frac{1}{5} \times \frac{1}{1.878} \times 10^{-4}$

$\Rightarrow m = 9.7 \times 10^{-28} kg$

Question95

The surface of a metal is illuminated alternately with photons of energies E_1 = 4 eV and E_2 = 2.5 eV respectively. The ratio of maximum speeds of the photoelectrons emitted in the two cases is 2. The work function of the metal in (eV) is ________.
[NA Sep. 05, 2020 (II)]

Answer: 2

Solution:

Solution:
From the Einstein's photoelectric equation
Energy of photon = Kinetic energy of photoelectrons + Work function
⇒ Kinetic energy = Energy of Photon − Work Function
Let ϕ_0 be the work function of metal and v_1 and v_2 be the velocity of photoelectrons. Using Einstein's photoelectric equation we have

$\frac{1}{2}mv_1{}^2 = 4 - \phi_0$ ......(i)

$\frac{1}{2}mv_2{}^2 = 2.5 - \phi_0$......(ii)

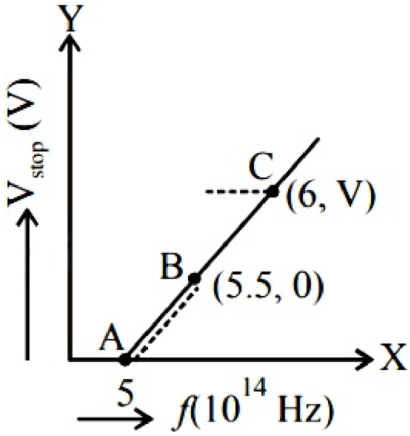
$\Rightarrow \frac{\frac{1}{2}mv_1{}^2}{\frac{1}{2}mv_2{}^2} = \frac{4-\phi_0}{2.5-\phi_0}$

$\Rightarrow (2)^2 = \frac{4-\phi_0}{2.5-\phi_0} \Rightarrow 10 - 4\phi_0 = 4 - \phi_0$

$\phi_0 = 2eV$

Question96

Given figure shows few data points in a photo electric effect experiment for a certain metal. The minimum energy for ejection of electron from its surface is : (Plancks constant h = 6.62×10^{-34} J.s)



[Sep. 04, 2020 (I)]

Options:

A. 2.27 eV

B. 2.59 eV

C. 1.93 eV

D. 2.10 eV

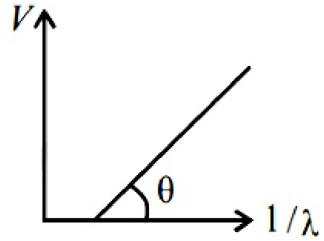
Answer: A

Solution:

Solution:
Graph of V and f given at B(5.5, 0)
Minimum energy for ejection of electron = Work function (ϕ).
$\phi = hV$ joule or $\phi = \frac{hV}{e} eV$ (for $V = 0$)
$\therefore \phi = \frac{6.62 \times 10^{-34} \times 5.5 \times 10^{14}}{1.6 \times 10^{-19}} eV = 2.27 eV$

Question97

In a photoelectric effect experiment, the graph of stopping potential V versus reciprocal of wavelength obtained is shown in the figure. As the intensity of incident radiation is increased :



[Sep. 04, 2020 (II)]

Options:

A. Straight line shifts to right

B. Slope of the straight line get more steep

C. Straight line shifts to left

D. Graph does not change

Answer: D

Solution:

According to Einstein's photoelectric equation
$K_{max} = hv - \phi_0$
$\Rightarrow eV_s = \frac{hc}{\lambda} - \phi_0$

$\Rightarrow V_s = \frac{hc}{\lambda e} - \frac{\phi_0}{e}$
where $\lambda =$ wavelength of incident light
$\phi_0 =$ work function
$V_s =$ stopping potential
Comparing the above equation with $y = mx + c$, we getslope $= \frac{hc}{e}$
Increasing the frequency of incident radiation has no effect on work function and frequency. So, graph will not change.

Question98

When the wavelength of radiation falling on a metal is changed from 500 nm to 200 nm, the maximum kinetic energy of the photoelectrons becomes three times larger. The work function of the metal is close to : [Sep. 03, 2020 (I)]

Options:

A. 0.81 eV

B. 1.02 eV

C. 0.52 eV

D. 0.61 eV

Answer: D

Solution:

Solution:
Using equation, $= \frac{hc}{\lambda} - \phi$
$KE_{max} = \frac{hc}{\lambda} - \phi = \frac{hc}{500} - \phi$ .....(1)
Again, $3KE_{max} = \frac{hc}{200} - \phi$ ......(2)
Dividing equation (2) by (1),
$$\frac{3KE_{max}}{KE_{max}} = \frac{3}{1} = \frac{\frac{hc}{200} - \phi}{\frac{hc}{500} - \phi}$$
Putting the value of $hc = 1237.5$ and solving we get, work function, $\phi = 0.61 eV$.

Question99

Two sources of light emit X-rays of wavelength 1 nm and visible light of wavelength 500 nm, respectively. Both the sources emit light of the same power 200 W. The ratio of the number density of photons of X-rays to the number density of photons of the visible light of the given wavelengths is : [Sep. 03, 2020 (II)]

Options:

A. $\frac{1}{500}$

B. 250

C. $\frac{1}{250}$

D. 500

Answer: A

Solution:

Solution:
Given,
Wavelength of X -rays, $\lambda_1 = 1\text{nm} = 1 \times 10^{-9}\text{m}$
Wavelength of visible light, $\lambda_2 = 500 \times 10^{-9}\text{m}$
The number of photons emitted per second from a source of monochromatic radiation of wavelength λ and power P is given as
$n = \frac{P}{E} = \frac{P}{hv} = \frac{P\lambda}{hc}$ $\left(\because E = hv \text{ and } v = \frac{c}{\lambda}\right)$
⇒ Clearly $n \propto \lambda$
$\Rightarrow \frac{n_1}{n_2} = \frac{\lambda_1}{\lambda_2} = \frac{1}{500}$

Question100

When radiation of wavelength λ is used to illuminate a metallic surface, the stopping potential is V. When the same surface is illuminated with radiation of wavelength 3λ , the stopping potential is . $\frac{V}{4}$. If the threshold wavelength for the metallic surface is nl then value of nλ will be ________.
[NA Sep. 02, 2020 (I)]

Answer: 9

Solution:

When radiation of wavelength A, λ_A is used to illuminate, stopping potential $V_A = V$
$\frac{hc}{\lambda} = \phi + eV$ .....(i)
When radiation of wavelength B, λ_B is used to illuminate, stopping potential, $V_B = \frac{V}{4}$
$\frac{hc}{3\lambda} = \phi + \frac{eV}{4}$ ....(ii)
From eq. (i) - (ii)
$\frac{hc}{\lambda}\left(1 - \frac{1}{3}\right) = \frac{3}{4}eV$
$\Rightarrow \frac{hc}{\lambda}\frac{2}{3} = \frac{3}{4}eV \Rightarrow eV = \frac{8}{9\lambda}$
$\frac{hc}{\lambda} = \phi + \frac{8}{9}\frac{hc}{\lambda}$

$\therefore \phi = \frac{hc}{9\lambda} = \frac{hc}{n\lambda}$, so, n = 9.

Question101

A particle A of mass 'm' and charge 'q' is accelerated by a potential difference of 50v Another particle B of mass 4m ' and charge'q is accelerated by a potential differnce of2500V . The ratio of de-Broglie wavelength $\frac{\lambda_A}{\lambda_B}$ is [12 Jan. 2019 I]

Options:

A. 10.00

B. 0.07

C. 14.14

D. 4.47

Answer: C

Solution:

Solution:
de Broglie wavelength (lambda) is given by $K = qV$
$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}} = \frac{h}{\sqrt{2mqV}} (\because p = \sqrt{2mK})$
Substituting the values we get
$\therefore \frac{\lambda_A}{\lambda_B} = \frac{\sqrt{2m_B q_B V_B}}{\sqrt{2m_A q_A V_A}} = \sqrt{\frac{4m \cdot q.2500}{m \cdot q.50}}$
$= 2\sqrt{50} = 2 \times 7.07 = 14.14$

Question102

If the deBroglie wavelength of an electron is equal to 10^{-3} times the wavelength of a photon of frequency 6×10^{14} Hz, then the speed of electron is equal to : (Speed of light $= 3 \times 10^8 m/s$) Planck's constant $= 6.63 \times 10^{-34} J.s$ Mass of electron $= 9.1 \times 10^{-31} kg$) [11 Jan. 2019 I]

Options:

A. $1.1 \times 10^6 m/s$

B. $1.7 \times 10^6 m/s$

C. $1.8 \times 10^6 m/s$

D. $1.45 \times 10^{6} \mathrm{m} / \mathrm{s}$

Answer: D

Solution:

Solution:
de-Broglie wavelength,

$$\lambda = \frac{h}{mv} = 10^{-3}\left(\frac{3 \times 10^{8}}{6 \times 10^{14}}\right) \left[\because \lambda = \frac{c}{v}\right]$$

$$v = \frac{6.63 \times 10^{-34} \times 6 \times 10^{14}}{9.1 \times 10^{-31} \times 3 \times 10^{5}}$$

$$v = 1.45 \times 10^{6} \mathrm{m} / \mathrm{s}$$

Question103

In an electron microscope, the resolution that can be achieved is of the order of the wavelength of electrons used. To resolve a width of 7.5×10^{-12} m, the minimum electron energy required is close to: [10 Jan. 2019 I]

Options:

A. 500 keV

B. 100 keV

C. 1 keV

D. 25 keV

Answer: D

Solution:

Using, $\lambda = \frac{h}{p}$ { given: $\lambda = 7.5 \times 10^{-12}$ }

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

Minimum energy required,

$$KE = \frac{P^{2}}{2m} = \frac{(h / \lambda)^{2}}{2m} = \frac{\left\{\frac{6.6 \times 10^{-34}}{7.5 \times 10^{-12}}\right\}^{2}}{2 \times 9.1 \times 10^{-31}} J = 25 keV$$

Question104

When a certain photosensistive surface is illuminated with monochromatic light of frequency v, the stopping potential for the photo current is $-V_{0} / 2$. When the surface is illuminated by monochromatic light of frequency $v / 2$, the stoppoing potential is $-V_{0}$.

The threshold frequency for photoelectric emission is:
[12 Jan. 2019 II]

Options:

A. $\frac{5v}{3}$

B. $\frac{4}{3}v$

C. 2v

D. (BONUS)

Answer: D

Solution:

Solution:
(BONUS)

Question105

In a Frank-Hertz experiment, an electron of energy 5.6 eV passes through mercury vapour and emerges with an energy 0.7 eV. The minimum wavelength of photons emitted by mercury atoms is close to : [12 Jan. 2019 II]

Options:

A. 1700 nm

B. 2020 nm

C. 220 nm

D. 250 nm

Answer: D

Solution:

Solution:
Using, wavelength, $\lambda = \frac{12375}{\Delta E}$
or, $\lambda = \frac{12375}{4.9} \simeq 250\text{nm}$

Question106

In a photoelectric experiment, the wavelength of the light incident on a metal is changed from 300 nm to 400 nm. The decrease in the stopping potential is close to :

$\left(\frac{hc}{e} = \mathbf{1240nm - V}\right)$
[11 Jan. 2019 II]

Options:

A. 0.5 V

B. 1.5 V

C. 1.0 V

D. 2.0 V

Answer: C

Solution:

Let $\phi =$ work function of the metal,
$\frac{hc}{\lambda_1} = \phi + eV_1$ ....(i)
$\frac{hc}{\lambda_2} = \phi + eV_2$ ....(ii)
Sutracting (ii) from (i) we get
$hc\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right) = e(V_1 - V_2)$

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

$\left[\lambda_1 = 300\,\text{nm}, \lambda_2 = 400\,\text{nm}, \frac{hc}{e} = 1240\,\text{nm} - \text{V}\right]$

$= (1240\text{nm} - \text{v})\left(\frac{100\text{nm}}{300\text{nm} \times 400\text{nm}}\right)$

$= 1.03\text{V} \approx 1\text{V}$

Question107

A metal plate of area $1 \times 10^{-4} m^2$ is illuminated by a radiation of intensity $16 mW / m^2$. The work function of the metal is $5eV$. The energy of the incident photons is $10eV$ and only 10% of it produces photo electrons. The number of emitted photo electrons per second and their maximum energy, respectively, will be:
$[1eV = 1.6 \times 10^{-19} J]$
[10 Jan. 2019 II]

Options:

A. 10^{14} and 10eV

B. 10^{12} and 5eV

C. 10^{11} and 5eV

D. 10^{10} and 5eV

Answer: C

Solution:

using, intensity $\mathrm{I} = \frac{\mathrm{nE}}{\mathrm{At}}$

$\mathrm{n} =$ no. of photoelectrons

$\Rightarrow 16 \times 10^{-3} = \left(\frac{\mathrm{n}}{\mathrm{t}}\right) \times \frac{10 \times 1.6 \times 10^{-19}}{10^{-4}}$ or, $\frac{\mathrm{n}}{\mathrm{t}} = 10^{12}$

So, effective number of photoelectrons ejected per unit time $= 10^{12} \times 10 / 100 = 10^{11}$

Question108

Surface of certain metal is first illuminated with light of wavelength λ_1 = 350 nm and then, by light of wavelength λ_2 = 540 nm. It is found that the maximum speed of the photo electrons in the two cases differ by a factor of (2)The work function of the metal (in eV) is close to: (Energy of photon $= \frac{1240}{\lambda(\text{ in nm})}\mathrm{eV}$) [9 Jan. 2019 I]

Options:

A. 1.8

B. 2.5

C. 5.6

D. 1.4

Answer: A

Solution:

Solution:

From Einstein's photoelectric equation,

$\frac{\mathrm{hc}}{\lambda_1} = \phi + \frac{1}{2}\mathrm{m}(2\mathrm{v})^2$ ......(i)

and $\frac{\mathrm{hc}}{\lambda_2} = \phi + \frac{1}{2}\mathrm{mv}^2$ ....(ii)

As per question, maximum speed of photoelectrons in two cases differ by a factor 2

From eqn. (i) & (ii)

$\Rightarrow \frac{\mathrm{hc}}{\lambda_1} - \frac{\phi}{\mathrm{hc}\lambda_2 - \phi} = 4 \Rightarrow \frac{\mathrm{hc}}{\lambda_1} - \phi = \frac{4\mathrm{hc}}{\lambda_2} - 4\phi$

$\Rightarrow \frac{4\mathrm{hc}}{\lambda_2} - \frac{\mathrm{hc}}{\lambda_1} = 3\phi \Rightarrow \phi = \frac{1}{3}\mathrm{hc}\left(\frac{4}{\lambda_2} - \frac{1}{\lambda_1}\right)$

$= \frac{1}{3} \times 1240\left(\frac{4 \times 350 - 540}{350 \times 540}\right) = 1.8\mathrm{eV}$

Question109

The magnetic field associated with a light wave is given at the origin by $\mathrm{B} = \mathrm{B}_0[\sin(3.14 \times 10^7)\mathrm{ct} + \sin(6.28 \times 10^7)\mathrm{ct}]$

If this light falls on a silver plate having a work function of 4.7 eV, what will be the maximum kinetic energy of thephotoelectrons?
$(c = 3 \times 10^8 ms^{-1}, h = 6.6 \times 10^{-34} J - s)$
[9 Jan. 2019 II]

Options:

A. 6.82 eV

B. 12.5 eV

C. 8.52 eV

D. 7.72 eV

Answer: D

Solution:

According to question, there are two EM waves with different frequency,
$B_1 = B_0 \sin(\pi \times 10^7 c) t$
and $B_2 = B_0 \sin(2\pi \times 10^7 c) t$
To get maximum kinetic energy we take the photon with higher frequency
using, $B = B_0 \sin \omega t$ and $\omega = 2\pi v \Rightarrow v = \omega 2\pi$
$B_1 = B_0 \sin(\pi \times 10^7 c) t \Rightarrow v_1 = \frac{10^7}{2} \times c$
$B_2 = B_0 \sin(2\pi \times 10^7 c) t \Rightarrow v_2 = 10^7 c$
where cis speed of light $c = 3 \times 10^8 m / s$
Clearly, $v_2 > v_1$
so KE of photoelectron will be maximum for photon of higher energy.
$v_2 = 10^7 cHz$
$hv = \phi + KE_{max}$
energy of photon
$E_{ph} = hv = 6.6 \times 10^{-34} \times 10^7 \times 3 \times 10^9$
$E_{ph}{}^{p_n} = 6.6 \times 3 \times 10^{-19} J$
$= \frac{6.6 \times 3 \times 10^{-19}}{1.6 \times 10^{-19}} eV = 12.375 eV$
$KE_{max} = E_{ph} - \phi$
$= 12.375 - 4.7 = 7.675 eV \approx 7.7 eV$

Question110

A particle ' P ' is formed due to a completely inelastic collision of particles ' x ' and ' y ' having de-Broglie wavelengths $'\lambda_x'$ and $'\lambda_y$ ' respectively. If x and y were moving in opposite directions, then the de-Broglie wavelength of ' P ' is:
[9 Apr. 2019 II]

Options:

A. $\frac{\lambda_x \lambda_y}{\lambda_x + \lambda_y}$

B. $\frac{\lambda_x \lambda_y}{|\lambda_x - \lambda_y|}$

C. $\lambda_x - \lambda_y$

D. $\lambda_x + \lambda_y$

Answer: B

Solution:

Solution:
$P_1 - P_2 = (P_1 + P_2) = P$
As $P \propto \frac{1}{\lambda}$
or $\frac{1}{\lambda_x} - \frac{1}{\lambda_y} = \frac{1}{\lambda}$
or $\frac{\lambda_y - \lambda_x}{\lambda_x \lambda_y} = \frac{1}{\lambda}$

Question111

Two particles move at right angle to each other. Their de Broglie wavelengths are λ_1 and λ_2 respectively. The particles suffer perfectly inelastic collision. The de Broglie wavelength λ, of the final particle, is given by:
[8 April 2019 I]

Options:

A. $\frac{1}{\lambda^2} = \frac{1}{\lambda_1^2} + \frac{1}{\lambda_2^2}$

B. $\lambda = \sqrt{\lambda_1 \lambda_2}$

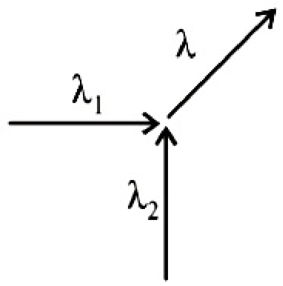
C. $\lambda = \frac{\lambda_2 + \lambda_2}{2}$

D. $\frac{2}{\lambda} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$

Answer: A

Solution:

Solution:
From the de-Broglie relation,



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

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

Momentum of the final particle (p_f) is given by

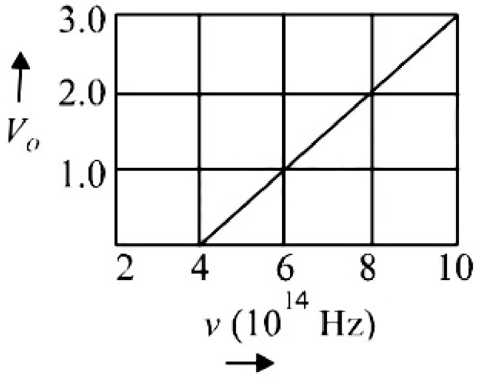
$\therefore p_f = \sqrt{p_1^2 + p_2^2}$

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

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

Question112

The stopping potential V_0 (in volt) as a function of frequency(v) for a sodium emitter, is shown in the figure. The work function of sodium, from the data plotted in the figure, will be: (Given : Planck's constant (h) = 6.63×10^{-34} J s, electron charge e = 1.6×10^{-19} C)



[12 Apr. 2019 I]

Options:

A. 1.82 eV

B. 1.66 eV

C. 1.95 eV

D. 2.12 eV

Answer: B

Solution:

Solution:

$f_0 = 4 \times 10^{14}$ Hz

$W_0 = hf_0 = 6.63 \times 10^{-34} \times (4 \times 10^{14})$ J

$= \frac{(6.63 \times 10^{-34}) \times (4 \times 10^{14})}{1.6 \times 10^{-19}}$

$= 1.66$ eV

Question113

In a photoelectric effect experiment the threshold wavelength of light is

380 nm. If the wavelength of incident light is 260 nm, the maximum kinetic energy of emitted electrons will be:
Given E (in eV) =
[10 Apr. 2019 I]

Options:

A. 1.5 eV

B. 3.0 eV

C. 4.5 eV

D. 15.1 eV

Answer: A

Solution:

Solution:
$KE_{max} = E - \phi_0$
(where E = energy of incident light ϕ_0 = work function)
$= \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$
$= 1237\left[\frac{1}{260} - \frac{1}{380}\right]$
$= \frac{1237 \times 120}{380 \times 260} = 1.5eV$

Question114

A 2mW laser operates at a wavelength of 500nm. The number of photons that will be emitted per second is :
[Given Planck's constant $h = 6.6 \times 10^{-34}$ J s, speed of light $c = 3.0 \times 10^8 m/s$]
[10 Apr. 2019 II]

Options:

A. 5×10^{15}

B. 1.5×10^{16}

C. 2×10^{16}

D. 1×10^{16}

Answer: A

Solution:

Solution:
Energy of photon (E) is given by
$E = \frac{hc}{\lambda}$
Number of photons of wavelength $lambda$ emitted in t second from laser of power P is given by

$n = \frac{Pt\lambda}{hc}$

$\Rightarrow n = \frac{2 \times \lambda}{hc} = \frac{2 \times 10^{-3} \times 5 \times 10^{-7}}{2 \times 10^{-25}} (\because t = 1S)$

$\Rightarrow n = 5 \times 10^{15}$

Question115

The electric field of light wave is given as

$$\vec{E} = 10^3 \cos\left(\frac{2\pi x}{5 \times 10^{-7}} - 2\pi \times 6 \times 10^{14} t\right) \hat{x} \frac{N}{C}$$

This light falls on a metal plate of work function 2eV. The stopping potential of the photo-electrons is:

Given, E (in eV) = $\frac{12375}{\lambda(\text{ in Å})}$

[9 April 2019 I]

Options:

A. 2.0 V

B. 0.72 V

C. 0.48 V

D. 2.48 V

Answer: C

Solution:

Solution:

Here $w = 2\pi \times 6 \times 10^{14}$ or $f = 6 \times 10^{14} Hz$

Wavelength $\lambda = \frac{C}{f} = \frac{3 \times 10^8}{6 \times 10^{14}} = 0.5 \times 10^{-6} m = 5000 A^{\circ}$

Now $E = \frac{12374}{5000} = 2.48 eV$

Using $E = w + eV$

$2.48 = 2 + eV_s$ or $V_s = 0.48V$

Question116

Two electrons are moving with non-relativistic speeds perpendicular to each other. If corresponding de Broglie wavelengths are λ_1 and λ_2, their de Broglie wavelength in the frame of reference attached to their centre of mass is:

[Online April 15, 2018]

Options:

A. $\lambda_{CM} = \lambda_1 = \lambda_2$

B. $\frac{1}{\lambda_1} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$

C. $\lambda_{CM} = \frac{2\lambda_1\lambda_2}{\sqrt{\lambda_1^2 + \lambda_2^2}}$

D. $\lambda_{CM} = \left(\frac{\lambda_1 + \lambda_2}{2}\right)$

Answer: C

Solution:

Solution:

Momentum (p) of each electron $\frac{h}{\lambda_1}\hat{i}$ and $\frac{h}{\lambda_2}\hat{j}$

Velocity of centre of mass

$V_{cm} = \frac{h}{2m\lambda_1}\hat{i} + \frac{h}{2m\lambda_2}\hat{j}\ (\because p = mv)$

Velocity of 1 st particle about centre of mass

$V_{1cm} = \frac{h}{2m\lambda_1}\hat{i} - \frac{h}{2m\lambda_2}\hat{j}$

$\lambda_{cm} = \frac{h}{\sqrt{\frac{h^2}{4\lambda_1^2} + \frac{h^2}{4\lambda_2^2}}} = \frac{2\lambda_1\lambda_2}{\sqrt{\lambda_1^2 + \lambda_2^2}}\left(\because \lambda = \frac{h}{p}\right)$

Question117

If the de Broglie wavelengths associated with a proton and an α-particle are equal, then the ratio of velocities of the proton and the α-particle will be:
[Online April 15, 2018]

Options:

A. 1 : 4

B. 1 : 2

C. 4 : 1

D. 2 : 1

Answer: C

Solution:

Solution:

According to question, $\lambda_p = \lambda_\alpha$

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

So, $\frac{h}{m_p \times v_p} = \frac{h}{m_\alpha \times v_\alpha}$

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

(∵ mass of α -particle is 4 times of mass of proton)

So, $\frac{v_p}{v_\alpha} = \frac{4}{1}$; i.e., 4 : 1

Question118

A particle A of mass m and initial velocity v collides with a particle B of mass $\frac{m}{2}$ which is at rest. The collision is head on, and elastic. The ratio of the de-Broglie wavelengths λ_A to λ_B after the collision is [2017]

Options:

A. $\frac{\lambda_A}{\lambda_B} = \frac{2}{3}$

B. $\frac{\lambda_A}{\lambda_B} = \frac{1}{2}$

C. $\frac{\lambda_A}{\lambda_B} = \frac{1}{3}$

D. $\frac{\lambda_A}{\lambda_B} = 2$

Answer: D

Solution:

Solution:

From question, $m_A = M$; $m_B = \frac{m}{2}$

$u_A = V \quad u_B = 0$

Let after collision velocity of $A = V_1$ and velocity of $B = V_2$

Applying law of conservation of momentum,

$mu = mv_1 + \left(\frac{m}{2}\right)v_2$

or, $24 = 2v_1 + v_2$ ......(i)

By law of collision

$e = \frac{v_2 - v_1}{u - 0}$

or, $u = v_2 - v_1$ ....(ii)

[∵ collision is elastic, e = 1]

using eqns (i) and (ii)

$v_1 = \frac{4}{3}$ and $v_2 = \frac{4}{3}u$

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

$\therefore \frac{\lambda_A}{\lambda_B} = \frac{P_B}{P_A} = \frac{\frac{m}{2} \times \frac{4}{3}u}{m \times \frac{4}{3}} = 2$

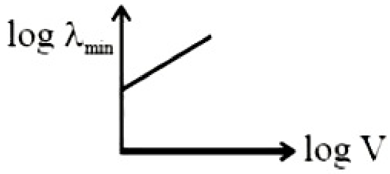
Question119

An electron beam is accelerated by a potential difference V to hit a

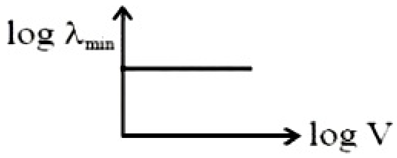
metallic target to produce X-rays. It produces continuous as well as characteristic X-rays.If λ_{min} is the smallest possible wavelength of X -ray in the spectrum, the variation of $\log \lambda_{min}$ with $\log V$ is correctly represented in :
[2017]

Options:

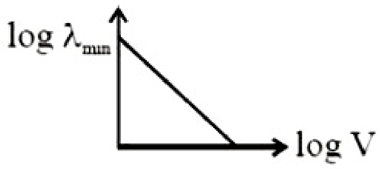
A.



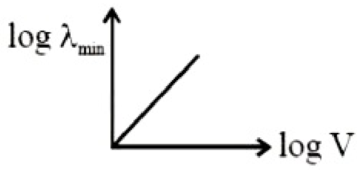
B.



C.



D.



Answer: C

Solution:

Solution:
In X -ray tube, $\lambda_{min} = \frac{hc}{eV}$
$\text{In}\,\lambda_{min} = \text{In}\left(\frac{hc}{e}\right) - \text{In}\,V$
Clearly, $\log \lambda_{min}$ versus $\log V$ graph
slope is negative hence option (c) correctly depicts.

Question120

A Laser light of wavelength 660nm is used to weld Retina detachment. If

a Laser pulse of width 60ms and power 0.5 kW is used the approximate number of photons in the pulse are : [Take Planck's constant $h = 6.62 \times 10^{-34}$ J s]
[Online April 9, 2017]

Options:

A. 10^{20}

B. 10^{18}

C. 10^{22}

D. 10^{19}

Answer: A

Solution:

Solution:
Given, $\lambda = 660\text{nm}$, Power $= 0.5\text{kW}$, $t = 60\text{ms}$
Power $P = \frac{nhc}{\lambda t} \Rightarrow n = \frac{p\lambda}{hc}$
$= 0.5 \times 10^3 \times \frac{660 \times 10^{-9} \times 60 \times 10^{-3}}{6.6 \times 10^{-34} \times 3 \times 10^8}$
$= 100 \times 10^{18} = 10^{20}$

Question121

The maximum velocity of the photoelectrons emitted from the surface is v when light of frequency n falls on a metal surface. If the incident frequency is increased to 3n, the maximum velocity of the ejected photoelectrons will be :
[Online April 8, 2017]

Options:

A. less than $\sqrt{3}v$

B. v

C. more than $\sqrt{3}v$

D. equal to $\sqrt{3}v$

Answer: C

Solution:

Solution:
As the metal surface is same, work function (ϕ) is same for both the case.
Initially $KE_{max} = nh - \phi$ ....(i)
After increase $KE_{max} = 3nh - \phi$ ..... (ii)
For work function ϕ− not to be − ve or zero, $v' > \sqrt{3}v$

Question122

Radiation of wavelength lambda, is incident on a photocell. The fastest emitted electron has speed v. If the wavelength is changed to $\frac{3\lambda}{4}$, the speed of the fastest emitted electron will be:
[2016]

Options:

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

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

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

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

Answer: C

Solution:

Solution:

$h\frac{c}{\lambda} - hv_0 = \frac{1}{2}mv^2$

$\therefore \frac{4}{3}\frac{hc}{\lambda} - hv_0 = \frac{1}{2}mv'^2$

$\therefore \frac{v'^2}{v^2} = \frac{\frac{4}{3}v - v_0}{v - v_0} \therefore v' = v\sqrt{\frac{\frac{4}{3}v - v_0}{v - v_0}}$

$\therefore v' > v\sqrt{\frac{4}{3}}$

Question123

A photoelectric surface is illuminated successively by monochromatic light of wavelengths λ and $\frac{\lambda}{2}$. If the maximum kinetic energy of the emitted photoelectrons in the second case is 3 times that in the first case, the work function of the surface is :
[Online April 10,2016]

Options:

A. $\frac{hc}{2\lambda}$

B. $\frac{hc}{\lambda}$

C. $\frac{hc}{3\lambda}$

D. $\frac{3hc}{\lambda}$

Answer: A

Solution:

Solution:
From Einstein's photoelectric equation

$K.E_{.\lambda} = \frac{hc}{\lambda} - \phi$ ....(i)

(for monochromatic light of wavelength λ) where ϕ is work function

$K.E_{.\frac{\lambda}{2}} = \frac{hc}{\lambda / 2} - \phi$ ....(ii)

(for monochromatic light of wavelength $\lambda / 2$)

From question,

$K.E._{\frac{\lambda}{2}} = 3(K.E._{\lambda}) \Rightarrow \frac{hc}{\lambda / 2} - \phi = 3\left(\frac{hc}{\lambda} - \phi\right)$

$\frac{2hc}{\lambda} - \phi = 3\frac{hc}{\lambda} - 3\phi$

$\Rightarrow 2\phi = \frac{hc}{\lambda} \therefore \phi = \frac{hc}{2\lambda}$

Question124

When photons of wavelength λ_1 are incident on an isolated sphere, the corresponding stopping potential is found to be V . When photons of wavelength λ_2 are used, the corresponding stopping potential was thrice that of the above value. If light of wavelength λ_3 is used then find the stopping potential for this case :
[Online April 9,2016]

Options:

A. $\frac{hc}{e}\left[\frac{1}{\lambda_3} + \frac{1}{\lambda_2} - \frac{1}{\lambda_1}\right]$

B. $\frac{hc}{e}\left[\frac{1}{\lambda_3} + \frac{1}{2\lambda_2} - \frac{1}{\lambda_1}\right]$

C. $\frac{hc}{e}\left[\frac{1}{\lambda_3} - \frac{1}{\lambda_2} - \frac{1}{\lambda_1}\right]$

D. (None)

Answer: D

Solution:

Solution:
From Einstein's photoelectric equation, we have

$\frac{hc}{\lambda_1} = \frac{hc}{\lambda_0} + eV$ ......(i)

$\frac{hc}{\lambda_2} = \frac{hc}{\lambda_0} + eV$ ....(ii)

$\frac{hc}{\lambda_3} = \frac{hc}{\lambda_0} + 3eV'$ ......(iii)

From equation (1)&(2)

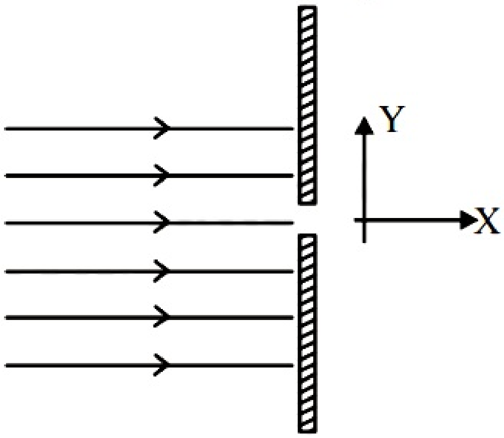
$\frac{3}{2\lambda_1} - \frac{2}{2\lambda_2} = \frac{1}{\lambda_0}$

$\frac{hc}{\lambda_1} - hc\left[\frac{3}{2\lambda_1} - \frac{1}{2\lambda_2}\right] = eV'$

$\frac{hc}{e}\left[\frac{1}{\lambda_3} - \frac{3}{2\lambda_1} + \frac{1}{2\lambda_2}\right] = V'$

Question125

A parallel beam of electrons travelling in x-direction falls on a slit of width d (see figure). If after passing the slit, an electron acquires momentum p_y in the y-direction then for a majority of electrons passing through the slit (h is Planck's constant) :



[Online April 10, 2015]

Options:

A. $|P_y|d > h$

B. $|P_y|d < h$

C. $|P_y|d \simeq h$

D. $|P_y|d >> h$

Answer: A

Solution:

Solution:
From Bragg's equation
$d \sin\theta = \lambda$

$\sin\theta = \frac{\lambda}{d} < 1 \therefore \lambda < d$

$\frac{h}{|p_y|} < d \left[\because \lambda = \frac{h}{|p_y|}\right]$

$\therefore h < |p_y| d$

Question126

de-Broglie wavelength of an electron accelerated by a voltage of 50V is close to ($|e| = 1.6 \times 10^{-19}C$, $m_e = 9.1 \times 10^{-31}kg$ $h = 6.6 \times 10^{-34}J\,s$): [Online April 10, 2015]

Options:

A. 2.4 Å

B. 0.5 Å

C. 1.7 Å

D. 1.2 Å

Answer: C

Solution:

Solution:
de-Broglie wavelength,

$$\lambda = \frac{h}{P} = \frac{h}{mv} = \frac{h}{\sqrt{2mqV}}$$

or, $\lambda = \frac{6.6 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19} \times 50}}$

$= 1.7Å$

Question127

For which of the following particles will it be most difficult to experimentally verify the de-Broglie relationship? [Online April 9, 2015]

Options:

A. an electron

B. a proton

C. an α-particle

D. a dust particle

Answer: D

Solution:

Solution:
Among the given particles most difficult to experimentally verify the de-broglie relationship is for a dust particle.

Question128

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

List - I	List - II
A . Franck-Hertz Experiment	(i) Particle nature of light
B. Photo-electric experiment	(ii) Discrete energylevels of atom
C. Davis on-Germer experiment	(iii) Wave nature ofelectron
	(iv) Structure of atom

[2015]

Options:

A. (A)-(ii); (B)-(i); (C)-(iii)

B. (A)-(iv); (B)-(iii); (C)-(ii)

C. (A)-(i); (B)-(iv); (C)-(iii)

D. (A)-(ii); (B)-(iv); (C)-(iii)

Answer: A

Solution:

Solution:
Frank-Hertz experiment - Discrete energy levels of atom, Photoelectric effect - Particle nature of light.
Davison - Germer experiment - wave nature of electron.

Question129

A beam of light has two wavelengths of 4972Å and 6216Å with a total intensity of $3.6 \times 10^{-3} \mathrm{W\,m^{-2}}$ equally distributed among the two wavelengths. The beam falls normally on an area of $1 \mathrm{cm}^2$ of a clean metallic surface of work function 2.3eV . Assume that there is no loss of light by reflection and that each capable photon ejects one electron. The number of photoelectrons liberated in 2 s is approximately:
[Online April 12,2014]

Options:

A. 6×10^{11}

B. 9×10^{11}

C. 11×10^{11}

D. 15×10^{11}

Answer: B

Solution:

Given, $\lambda_1 = 4972Å$
and $\lambda_2 = 6216Å$
and $I = 3.6 \times 10^{-3} W\, m^{-2}$
Intensity associated with each wavelength
$= \frac{3.6 \times 10^{-3}}{2}$
$= 1.8 \times 10^{-3} W\, m^{-2}$
work function $\phi = hv$
$= \frac{hc}{\lambda}$
$= \frac{(6.62 \times 10^{-34})(3 \times 10^8)}{\lambda}$
$= \frac{12.4 \times 10^3}{\lambda} ev$
for different wavelengths
$\phi_1 = \frac{12.4 \times 10^3}{\lambda_1} = \frac{12.4 \times 10^3}{4972} = 2.493 eV = 3.984 \times 10^{-19} J$
$\phi_2 = \frac{12.4 \times 10^3}{\lambda_2} = \frac{12.4 \times 10^3}{6216} = 1.994 eV = 3.184 \times 10^{-19} J$
Work function for metallic surface $\phi = 2.3 eV$ (given)
$\phi_2 < \phi$
Therefore, ϕ_2 will not contribute in this process.
Now, no. of electrons per $m^2 - s$ = no. of photons per $m^2 - s$
no. of electrons per $m^2 - s = \frac{1.8 \times 10^{-3}}{3.984 \times 10^{-19}} \times 10^{-4}$
$(\because 1 cm^2 = 10^{-4} m^2) = 0.45 \times 10^{12}$
So, the number of photo electrons liberated in 2 sec.
$= 0.45 \times 10^{12} \times 2$
$= 9 \times 10^{11}$

Question130

A photon of wavelength λ is scattered from an electron, which was at rest. The wavelength shift $\Delta\lambda$ is three times of λ and the angle of scattering θ is 60°. The angle at which the electron recoiled is ϕ. The value of $\tan\phi$ is : (electron speed is much smaller than the speed of light)
[Online April 11,2014]

Options:

A. 0.16

B. 0.22

C. 0.25

D. 0.28

Answer: B

Solution:

Solution:

Question131

Electrons are accelerated through a potential difference V and protons are accelerated through a potential difference 4V . The de-Broglie wavelengths are λ_e and λ_p for electrons and protons respectively. The ratio of $\frac{\lambda_e}{\lambda_n}$ is given by : (given m_e is mass of electron and m_p is mass of proton).
[Online April 23, 2013]

Options:

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

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

C. $\frac{\lambda_e}{\lambda_p} = \frac{1}{2}\sqrt{\frac{m_e}{m_p}}$

D. $\frac{\lambda_e}{\lambda_p} = 2\sqrt{\frac{m_p}{m_e}}$

Answer: D

Solution:

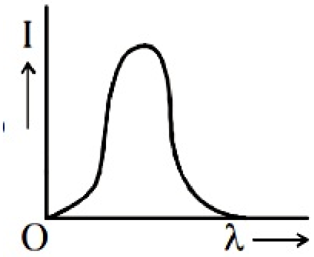
Solution:
Energy in joule (E) = charge × potential diff. in volt
$E_{electron} = q_e V$ and $E_{proton} = q_p 4V$
de-Broglie wavelength $\lambda = \frac{h}{P} = \frac{h}{\sqrt{2mE}}$
$\lambda_e = \frac{h}{\sqrt{2m_e eV}}$ and $\lambda_P = \frac{h}{\sqrt{2m_P e4V}} (\because q_e = q_P)$
$\therefore \frac{\lambda_e}{\lambda_P} = \frac{\frac{h}{\sqrt{2m_e eV}}}{\frac{h}{\sqrt{2m_p e4V}}} = \sqrt{\frac{2m_P e4V}{2m_e eV}} = 2\sqrt{\frac{m_P}{m_e}}$

Question132

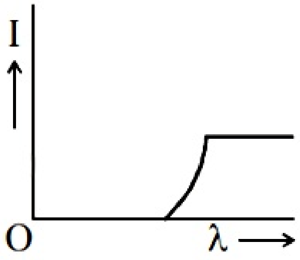
The anode voltage of a photocell is kept fixed. The wavelength λ of the light falling on the cathode is gradually changed. The plate current I of the photocell varies as follows :
[2013]

Options:

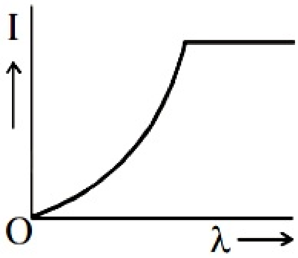
A.



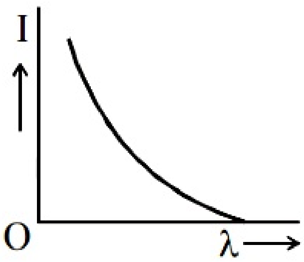
B.



C.



D.



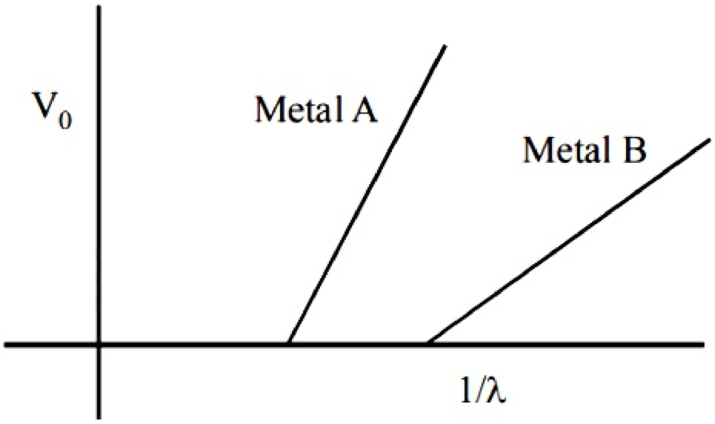
Answer: D

Solution:

Solution:
As λ is increased, there will be a value of λ above which photoelectrons will be cease to come out so photocurrent will become zero. Hence (d) is correct answer.

Question133

In an experiment on photoelectric effect, a student plots stopping potential V_0 against reciprocal of the wavelength λ of the incident light for two different metals A and B These are shown in the figure.



Looking at the graphs, you can most appropriately say that:
[Online April 25, 2013]

Options:

A. Work function of metal B is greater than that of metal A

B. For light of certain wavelength falling on both metal, maximum kinetic energy of electrons emitted from A will be greater than those emitted from B.

C. Work function of metal A is greater than that of metal B

D. Students data is not correct

Answer: D

Solution:

Solution:

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

$v_0 = \frac{hc}{e\lambda} - \frac{\phi}{e}$

For metal A

$\frac{\phi A}{hc} = \frac{1}{\lambda}$

For metal B

$\frac{\phi B}{hc} = \frac{1}{\lambda}$

As the value of $\frac{1}{\lambda}$ (increasing and decreasing) is not specified hence we cannot say that which metal has comparatively greater or lesser work function (ϕ).

Question134

A copper ball of radius 1 cm and work function 4.47eV is irradiated with ultraviolet radiation of wavelength 2500 Å. The effect of irradiation results in the emission of electrons from the ball. Further the ball will acquire charge and due to this there will be a finite value of the potential on the ball. The charge acquired by the ball is :
[Online April 25, 2013]

Options:

A. 5.5×10^{-13}C

B. 7.5×10^{-13}C

C. 4.5×10^{-12}C

D. 2.5×10^{-11}C

Answer: A

Solution:

Solution:

Question135

This equation has statement 1 and statement 2. Of the four choices given after the statements, choose the one that describes the two statements.
Statement 1: Davisson-Germer experiment established the wave nature of electrons.
Statement 2 : If electrons have wave nature, they can interfere and show diffraction.
[2012]

Options:

A. Statement 1 is false, Statement 2 is true.

B. Statement 1 is true, Statement 2 is false

C. Statement 1 is true, Statement 2 is true, Statement 2 is the correct explanation of statement 1

D. Statement 1 is true, Statement 2 is true, Statement 2 is not the correct explanation of Statement 1

Answer: A

Solution:

Solution:
Davisson Germer experiment showed that electron beams can undergo diffraction when passed through atomic crystal. This established wave nature of electron as waves can exhibit interference and diffraction.

Question136

Photoelectrons are ejected from a metal when light of frequency υ falls on it. Pick out the wrong statement from the following.
[Online May 26, 2012]

Options:

A. No electrons are emitted if υ is less than W/h, where W is the work function of the metal

B. The ejection of the photoelectrons is instantaneous.

C. The maximum energy of the photoelectrons is hυ.

D. The maximum energy of the photoelectrons isindependent of the intensity of the light.

Answer: C

Solution:

Solution:
According to photo-electric equation:
$K.E_{max} = hv - hv_0$ (Work function)
Some sort of energy is used in ejecting the photoelectrons.

Question137

This question has Statement 1 and Statement 2. Of the four choices given after the Statements, choose the one that best describes the two Statements.
Statement 1: A metallic surface is irradiated by a monochromatic light of frequency $\upsilon > \upsilon_0$ (the threshold frequency). If the incident frequency is now doubled, the photocurrent and the maximum kinetic energy are also doubled.
Statement 2: The maximum kinetic energy of photoelectrons emitted from a surface is linearly dependent on the frequency of the incident light. The photocurrent depends only on the intensity of the incident light.
[Online May 19, 2012]

Options:

A. Statement 1 is true, Statement 2 is true, Statement 2 is the correct explanation of Statement 1.

B. Statement 1 is false, Statement 2 is true.

C. Statement 1 is true, Statement 2 is false.

D. Statement 1 is true, Statement 2 is true, Statement 2 is not the correct explanation of Statement 1.

Answer: B

Solution:

Solution:
The maximum kinetic energy of photoelectrons depends upon frequency on incident light and photo current depends upon intensity of incident light.

Question138

This question has Statement -1 and Statement −2. Of the four choices given after the statements, choose the one that best describes the two statements.
Statement -1 : 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.
[2011]

Options:

A. Statement–1 is true, Statement–2 is true, Statement – 2 is the correct explanation of Statement – 1.

B. Statement–1 is true, Statement–2 is true, Statement – 2 is not the correct explanation of Statement – 1.

C. Statement – 1 is false, Statement – 2 is true.

D. Statement – 1 is true, Statement – 2 is false

Answer: C

Solution:

Solution:
By Einstein photoelectric equation,
$K_{max} = eV_0 = hv - hv_0$
When v is doubled, K_{max} and V_0 become more than double.

Question139

Statement -1 : When ultraviolet light is incident on a photocell, its stopping potential is V_0 and the maximum kinetic energy of the photoelectrons is K_{max}. When the ultraviolet light is replaced by X -rays, both V_0 and K_m 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.
[2010]

Options:

A. Statement -1 is true, Statement -2 is true ; Statement -2 is the correct explanation of Statement -1

B. Statement -1 is true, Statement -2 is true; Statement -2 is not the correct explanation of Statement -1

C. Statement -1 is false, Statement -2 is true.

D. Statement -1 is true, Statement -2 is false.

Answer: D

Solution:

Solution:
We know that
$eV_0 = K_{max} = hv - \phi$
where, ϕ is the work function.
X-rays have higher frequency (v) than ultraviolet rays. Therefore as v increases $K.E$ and V_0 both increases.
The kinetic energy ranges from zero to maximum because of loss of energy due to subsequent collisions before getting ejected.

Question140

The surface of a metal is illuminted with the light of 400 nm. The kinetic energy of the ejected photoelectrons was found to be 1.68 eV. The work function of the metal is : (hc = 1240 eV.nm) [2009]

Options:

A. 1.41 eV

B. 1.51 eV

C. 1.68 eV

D. 3.09 eV

Answer: A

Solution:

Solution:
Wavelength of incident light, $\lambda = 400\text{nm} hc = 1240$ eV.nm
$K.E = 1.68\text{eV}$
Using Einstein's photoelectric equation
$\frac{hc}{\lambda} - W = K.E$
$\Rightarrow W = \frac{hc}{\lambda} - K.E$
$\Rightarrow W = \frac{1240}{400} - 1.68$
$= 3.1 - 1.68$
$= 1.41\text{eV}$

Question141

Electrons accelerated by potential V are diffracted from a crystal. If $d = 1Å$ and $i = 30°$, V should be about ($h = 6.6 \times 10^{-34}$ J s, $m_e = 9.1 \times 10^{-31}$ kg, $e = 1.6 \times 10^{-19}$ C)
[2008]

Options:

A. 2000 V

B. 50 V

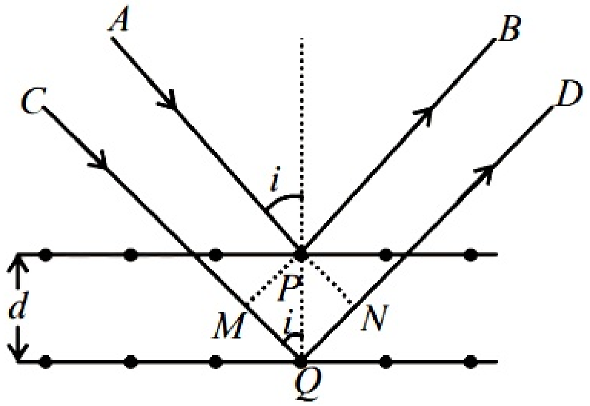
C. 500 V

D. 1000 V

Answer: B

Solution:

Solution:
The path difference between the rays APB and CQD is
$\Delta x = MQ + QN = d\cos i + d\cos i$
$\Delta x = 2d\cos i$



For constructive interference the path difference is integral multiple of wavelength
$\therefore n\lambda = 2d\cos i$
From de-broglie concept
Wavelength,
$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK.E}} = \frac{h}{\sqrt{2meV}}$
$\therefore \frac{nh}{\sqrt{2meV}} = 2d\cos i$
Squaring both side
$\frac{n^2h^2}{2meV} = 4d^2\cos^2 i$
For first order interference $n = 1$
$\therefore V = \frac{h^2}{8med^2\cos^2 i}$
$= \frac{(6.6 \times 10^{-34})^2}{8 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19} \times (10^{-10})^2 \times \cos^2 30}$
$= 50V$

Question142

If a strong diffraction peak is observed when electrons are incident at an angle ' i ' from the normal to the crystal planes with distance ' d ' between them (see figure), de Broglie wavelength λ_{dB} of electrons can

be calculated by the relationship (n is an integer) [2008]

Options:

A. $d \sin i = n\lambda_{dB}$

B. $2d \cos i = n\lambda_{dB}$

C. $2d \sin i = n\lambda_{dB}$

D. $d \cos i = n\lambda_{dB}$

Answer: B

Solution:

Solution:
For constructive interference,
$2d \cos i = n\lambda_{dB}$

Question143

Photon of frequency v has a momentum associated with it. If c is the velocity of light, the momentum is [2007]

Options:

A. hv / c

B. v / c

C. hvc

D. hv / c^2

Answer: A

Solution:

Solution:
Energy of a photon of frequency v is given by $E = hv$
Also, $E = mc^2$, $mc^2 = hv$
$\Rightarrow mc = \frac{hv}{c} \Rightarrow p = \frac{hv}{c}$

Question144

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 5 V. The incident radiation lies in

[2006]

Options:

A. ultra-violet region

B. infra-red region

C. visible region

D. X-ray region

Answer: A

Solution:

Work function, $\phi = 6.2\text{eV} = 6.2 \times 1.6 \times 10^{-19}\text{J}$
Stopping potential, V = 5 volt
From the Einstein's photoelectric equation

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

$$\Rightarrow \lambda = \frac{hc}{\phi + eV_0}$$

$$= \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{1.6 \times 10^{-19}(6.2 + 5)} \approx 10^{-7}\text{m}$$

This range lies in ultra violet range.

Question145

The time taken by a photoelectron to come out after the photon strikes is approximately
[2006]

Options:

A. 10^{-4}s

B. 10^{-10}s

C. 10^{-16}s

D. 10^{-1}s

Answer: B

Solution:

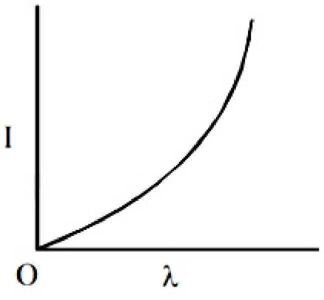
Solution:
The photoelectric emission is an instantaneous process without any apparent time lag. It is known that emission starts in the time of the order of 10^{-9} second. So, the approximate time taken by a photoelectron to come out after the photon strikes is 10^{-10} second.

Question146

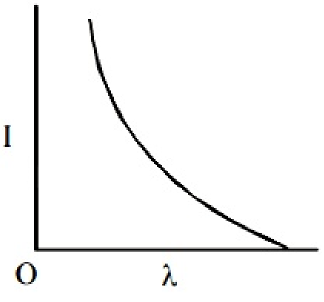
The anode voltage of a photocell is kept fixed. The wavelength λ of the light falling on the cathode is gradually changed. The plate current I of the photocell varies as follows
[2006]

Options:

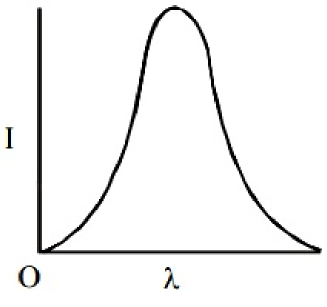
A.



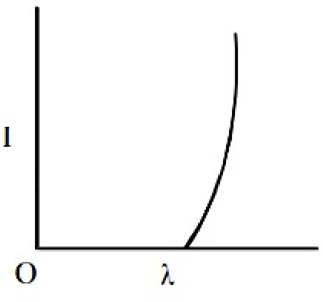
B.



C.



D.



Answer: B

Solution:

As λ decreases, y increases and hence the speed of photoelectron increases. The chances of photo electron to meet the anode increases and hence photo electric current increases.

Question147

If the kinetic energy of a free electron doubles, it's de-Broglie wavelength changes by the factor
[2005]

Options:

A. 2

B. $\frac{1}{2}$

C. $\sqrt{2}$

D. $\frac{1}{\sqrt{2}}$

Answer: D

Solution:

de-Broglie wavelength,
$\lambda = \frac{h}{p} = \frac{h}{mv}$
but $K.E = \frac{1}{2}mv^2$
$\Rightarrow K.E = \frac{(mv)^2}{2m}$
$\Rightarrow mv = \sqrt{2mK.E}$
$\lambda = \frac{h}{\sqrt{2mK.E}}$
$\therefore \lambda \propto \frac{1}{\sqrt{K.E}}$
So, if $K.E.$ is doubled, wavelength becomes $\frac{\lambda}{\sqrt{2}}$

Question148

A photocell is illuminated by a small bright source placed 1m away. When the same source of light is placed $\frac{1}{2}$m away, the number of electrons emitted by photocathode would
[2005]

Options:

A. increase by a factor of 4

B. decrease by a factor of 4

C. increase by a factor of 2

D. decrease by a factor of 2

Answer: A

Solution:

Solution:

$I \propto \frac{I}{r^2}; \frac{I_1}{I_2} = \left(\frac{r_2}{r_1}\right)^2 = \frac{1}{4}$

$I_2 \rightarrow 4 \times I_1$

When intensity becomes 4 times, no. of photoelectrons emitted would increase by 4 times, since number of electrons emitted per second is directly proportional to intensity.

Question149

A radiation of energy E falls normally on a perfectly reflecting surface. The momentum transferred to the surface is [2004]

Options:

A. Ec

B. $2E / c$

C. E / c

D. E / c^2

Answer: B

Solution:

Solution:

Momentum of photon of energy E is $= \frac{E}{c}$

When a photon hits a perfectly reflecting surface, it reflects black in opposite direction with same energy and momentum.

$\therefore$ Change in momentum $= \frac{E}{C} - \left(\frac{-E}{C}\right) = \frac{2E}{C}$

This is equal to momentum transferred to the surface.

Question150

According to Einstein's photoelectric equation, the plot of the kinetic energy of the emitted photo electrons from a metal Versus the frequency, of the incident radiation gives a straight line whose slope [2004]

Options:

A. depends both on the intensity of the radiation and the metal used

B. depends on the intensity of the radiation

C. depends on the nature of the metal used

D. is the same for the all metals and independent of the intensity of the radiation

Answer: D

Solution:

Solution:
From the Einstein photoelectric equation $K.E. = h\nu - \phi$
Here, $\phi =$ work function of metal
$h =$ Plank's constant
slope of graph of $K.E.$ & ν is h (Plank's constant) which is same for all metals.

Question151

The work function of a substance is 4.0 eV. The longest wavelength of light that can cause photoelectron emission from this substance is approximately
[2004]

Options:

A. 310 nm

B. 400 nm

C. 540 nm

D. 220 nm

Answer: A

Solution:

Solution:
Work function of metal (ϕ) is given by

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

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

$$\Rightarrow \lambda = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{4 \times 1.6 \times 10^{-19}} = 310\text{nm}$$

Question152

Two identical photocathodes receive light of frequencies f_1 and f_2. If the velocites of the photo electrons (of mass m) coming out are respectively v_1 and v_2, then
[2003]

Options:

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

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

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

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

Answer: A

Solution:

Solution:
Let work function be W and v_1 and v_2 be the velocity of electrons for frequencies f_1 and f_2.
Using Einstein's photo electric equation for one photodiode, we get
$hf_1 - W = \frac{1}{2}mv_1^{\ 2}$ ......(i)
Using Einstein's photo electric equation for another photodiode we get
$hf_2 - W = \frac{1}{2}mv_2^{\ 2}$ ......(ii)
Subtracting (ii) from (i) we get
$(hf_1 - W) - (hf_2 - W) = \frac{1}{2}mv_1^{\ 2} - \frac{1}{2}mv_2^{\ 2}$
$\therefore h(f_1 - f_2) = \frac{m}{2}(v_1^{\ 2} - v_2^{\ 2})$
$\therefore v_1^{\ 2} - v_2^{\ 2} = \frac{2h}{m}(f_1 - f_2)$

Question153

Formation of covalent bonds in compounds exhibits [2002]

Options:

A. wave nature of electron

B. particle nature of electron

C. both wave and particle nature of electron

D. none of these

Answer: A

Solution:

Solution:
Covalent bonds are formed by sharing of electrons with different compounds. Formation of covalent bond is best explained by molecular orbital theory.

Question154

Sodium and copper have work functions 2.3 eV and 4.5 eV respectively. Then the ratio of the wavelengths is nearest to
[2002]

Options:

A. 1 : 2

B. 4 : 1

C. 2 : 1

D. 1 : 4

Answer: C

Solution:

We know that work function,

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

where

h = Planck's constant

C = velocity of light

λ = wavelength of light

$\therefore \frac{E_{Na}}{E_{Cu}} = \frac{\lambda_{Cu}}{\lambda_{Na}}$

$\Rightarrow \frac{\lambda_{Na}}{\lambda_{Cu}} = \frac{E_{Cu}}{E_{Na}} = \frac{4.5}{2.3} \approx \frac{2}{1}$
