Dual Nature Of Matter And Radiation JEE Main PYQ

Total Time: 25 Minute **Total Marks:** 40

Instructions

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1. Test will auto submit when the Time is up.
2. The Test comprises of multiple choice questions (MCQ) with one or more correct answers.
3. The clock in the top right corner will display the remaining time available for you to complete the examination.

Navigating & Answering a Question

1. The answer will be saved automatically upon clicking on an option amongst the given choices of answer.
2. To deselect your chosen answer, click on the clear response button.
3. The marking scheme will be displayed for each question on the top right corner of the test window.

Dual Nature Of Matter And Radiation

1. The potential difference applied to an X-ray tube is increased. As a result, in the emitted radiation **(+4, -1)**
[30-Jan-2023•Shift•2]

a. the intensity increases

b. the minimum wavelength increases

c. the intensity remains unchanged

d. the minimum wavelength decreases

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2. Given below are two statements : Two photons having equal linear momenta have equal wavelengths. 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. **(+4, -1)**
[25-Jan-2023•Shift•2]

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

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3. Radiation of wavelength λ, is incident on a photocell. The fastest emitted electron has speed v. If the wavelength is changed to $\frac{3\lambda}{4}$, the speed of the fastest emitted electron will be : **(+4, -1)**
[31-Jan-2023•Shift•2]

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

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

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

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

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4. Surface of certain metal is first illuminated with light of wavelength $\lambda_1 = 350\ nm$ and then, by light of wavelength $\lambda_2 = 54\ nm$. 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 : (Energjr of photon = $\frac{1240}{\lambda(in\ nm)} eV$) [9•Jan.•2019•I] **(+4, -1)**

a. 1.8

b. 1.4

c. 2.5

d. 5.6

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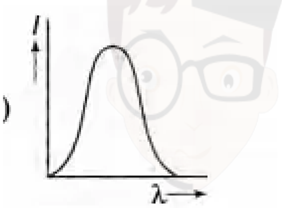
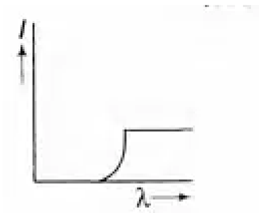
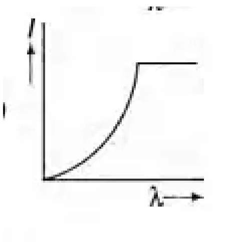
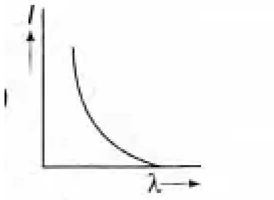
5. The anode voltage of a photocell is kept fixed. The wavelength λ of the light falling on the cathode is gradually changed. The plate current I of photocell varies as follows [2013] **(+4, -1)**

a. 

b. 

c. 

d. 

6. 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: **(+4, -1)**

[1-Feb-2023•Shift•1]

a. $2:1$

b. $4:1$

c. $1:4$

d. $1:2$

7. Given below are two statements : **(+4, -1)**
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

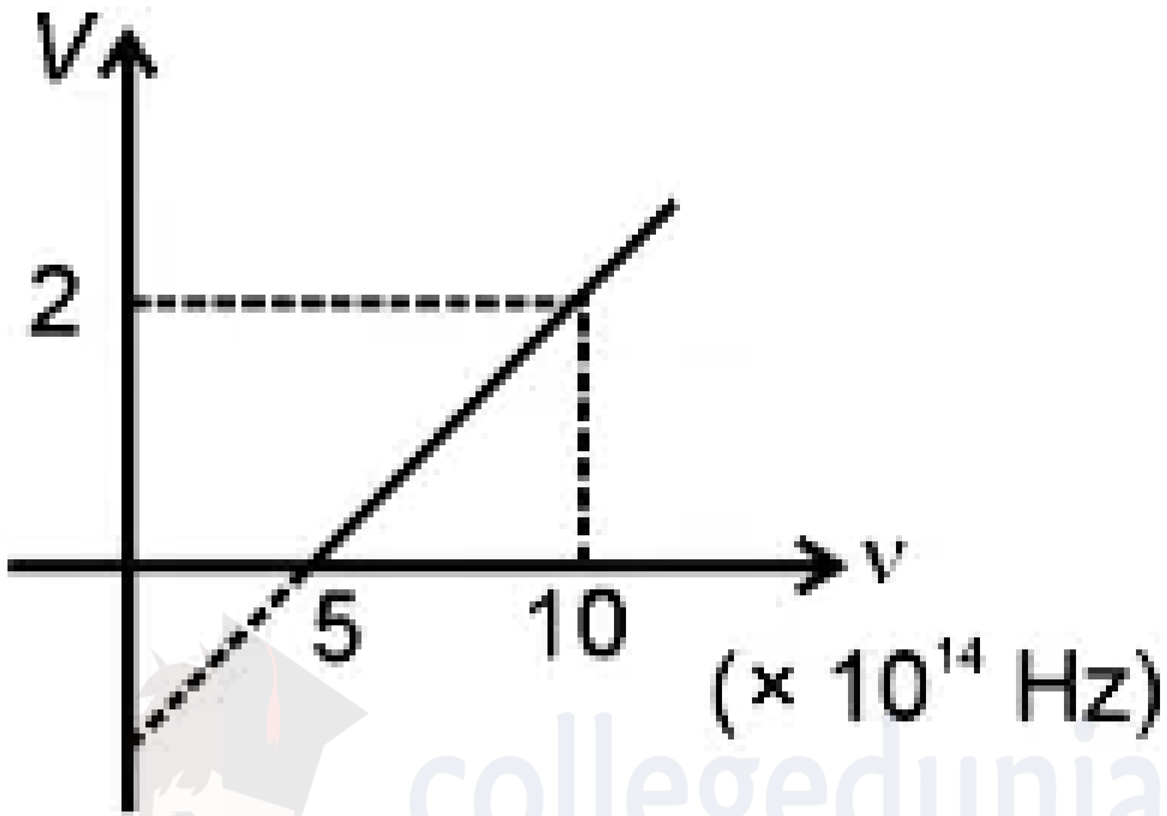
[25-Jan-2023•Shift•2]

a. Both Statement I and Statement II are incorrect

b. Statement I is correct but statement II is incorrect

c. Both Statement I and statement II are correct

d. Statement I is incorrect but statement II is correct



8. Based on given graph between stopping potential and frequency of irradiation, work function of metal is equal to **(+4, -1)**
[28-Jun-2022-Shift-1]

a. 1 eV

b. 3 eV

c. 2 eV

d. 4 eV

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9. The de - Broglie wavelength associated with the electron in the $n = 4$ level is : **(+4, -1)**
[1-Feb-2024•Shift•1]

a. two times the de-Broglie wavelength of the electron in the ground state

b. four times the de-Broglie wavelength of the electron in the ground state

c. half of the de-Broglie wavelength of the electron in the ground state

d. 1/4th of the de-Broglie wavelength of the electron in the ground state

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10. The de Broglie wavelength of an electron moving with a velocity 1.5×10^8 m/s is equal to that of a photon. The ratio of the energy of the photon to the kinetic energy of the electron is ______. [Online April 15, 2018] **(+4, -1)**

Answers

1. **Answer: d**

Explanation:

$\lambda_m(inA) = \frac{12375}{V(involt)}$
With increase in V, λ_m will decrease. With decrease in
λ_m energy of emitted photons will increase.
And hence intensity will increase even if number of photons
emitted per second are constant. Because intensity is basically
energy per unit area per unit time.

Concepts:

1. Photoelectric Effect:

When light shines on a metal, electrons can be ejected from the surface of the metal in a phenomenon known as the photoelectric effect. This process is also often referred to as photoemission, and the electrons that are ejected from the metal are called photoelectrons.

Photoelectric Effect Formula:

According to Einstein's explanation of the photoelectric effect :

The energy of photon = energy needed to remove an electron + kinetic energy of the emitted electron

i.e. hν = W + E

Where,

- h is Planck's constant.
- ν is the frequency of the incident photon.
- W is a work function.
- E is the maximum kinetic energy of ejected electrons: 1/2 mv^2.

Laws of Photoelectric Effect:

1. The photoelectric current is in direct proportion to the intensity of light, for a light of any given frequency; (γ > γ Th).
2. There exists a certain minimum (energy) frequency for a given material, called threshold frequency, below which the discharge of photoelectrons stops completely, irrespective of how high the intensity of incident light is.
3. The maximum kinetic energy of the photoelectrons increases with the increase in the frequency (provided frequency γ > γ Th exceeds the threshold limit) of the incident light. The maximum kinetic energy is free from the intensity of light.
4. The process of photo-emission is an instantaneous process.

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2. Answer: d

Explanation:

If linear momentum are equal then wavelength also equal

$p = \frac{h}{\lambda}, E = \frac{hc}{\lambda}$

On decreasing wavelength, momentum and energy of photon increases.

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3. **Answer: a**

Explanation:

$\frac{hc}{\lambda} - \phi = \frac{1}{2}mv^2$ .....(i) $\frac{4hc}{3\lambda} - \phi = \frac{1}{2}mv'^2$ ....(ii) $\frac{hc}{3\lambda} = \frac{1}{2}m\left(v'^2 - v^2\right) \Rightarrow v' = \sqrt{v^2 + \frac{2hc}{3\lambda m}}$ ....(iii) also from $\frac{hc}{\lambda} = \phi + \frac{mv^2}{2} \Rightarrow \frac{2hc}{\lambda m} = \frac{2\phi}{m} + v^2$ /. $\Rightarrow \frac{2hc}{3\lambda m} = \frac{2\phi}{3m} + \frac{r^2}{3} > \frac{v^2}{3}$ .....(iv) combining (iii) & (iv) $v' > \sqrt{\frac{4v^2}{3}}$

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4. Answer: a

Explanation:

$$\frac{hc}{\lambda_1} = \phi + \frac{1}{2}m\left(2v\right)^2 \quad \frac{hc}{\lambda_2} = \phi + \frac{1}{2}mv^2 \Rightarrow \frac{\frac{hc}{\lambda_1} - \phi}{\frac{hc}{\lambda_2} - \phi} = 4 \Rightarrow \frac{hc}{\lambda_1} - \phi = \frac{4hc}{\lambda_2} - 4\phi \Rightarrow \frac{4hc}{\lambda_2} - \frac{hc}{\lambda_1} = 3\phi \Rightarrow \phi = \frac{1}{3}hc\left(\frac{4}{\lambda_2} - \frac{1}{\lambda_1}\right) = \frac{1}{3} \times 1240\left(\frac{4\times350-540}{350\times540}\right) = 1.8\,eV$$

Concepts:

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5. **Answer: d**

Explanation:

As λ is increased, there will be a value of λ above which photoelectron will cease to come out. So, photocurrent will be zero.

Concepts:

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6. **Answer: b**

Explanation:

The correct option is(B): 4:1

$$KE = \frac{p^2}{2m} = \frac{h^2}{2m\lambda^2}$$
$$\frac{KE_p}{KE_\alpha} = \frac{m_\alpha}{m_p} = 4:1$$

Concepts:

1. Dual Nature of Radiation and Matter:

The dual nature of matter and the dual nature of radiation were throughgoing concepts of physics. At the beginning of the 20th century, scientists untangled one of the best-kept secrets of nature – the wave-particle duplexity or the dual nature of m atter and radiation.

Electronic Emission

The least energy that is needed to emit an electron from the surface of a metal can be supplied to the loose electrons.

Photoelectric Effect

The photoelectric effect is a phenomenon that involves electrons getting away from the surface of materials.

Heisenberg's Uncertainty Principle

Heisenberg's Uncertainty Principle states that both the momentum and position of a particle cannot be determined simultaneously.

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7. **Answer: c**

Explanation:

Stopping potential $V_S = \frac{KE_{\max}}{e}$
$$V_S = \frac{\frac{hC}{\lambda} - \phi}{e}$$
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

Concepts:

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4. The process of photo-emission is an instantaneous process.

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8. Answer: c

Explanation:

The correct answer is option (C) : 2 eV

$eV_5 = h_v - \phi$

On extrapolating the graph , the graph cuts the yaxis at -2

$\Rightarrow$ at v=0,v_s=-2v

$\Rightarrow \phi = 2\,eV$

Concepts:

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9. Answer: b

Explanation:

$\lambda = \frac{h}{mv} = \frac{h}{m\left(\beta \frac{z}{\mu}\right)}$,

where $\beta =$ constant and $n =$ orbit number

$\Rightarrow \lambda \propto n \Rightarrow \lambda_4 = 4\lambda_1$

Concepts:

1. De Broglie Hypothesis:

One of the equations that are commonly used to define the wave properties of matter is the de Broglie equation. Basically, it describes the wave nature of the electron.

De Broglie Equation Derivation and de Broglie Wavelength

Very low mass particles moving at a speed less than that of light behave like a particle and waves. De Broglie derived an expression relating to the mass of such smaller particles and their wavelength.

Plank's quantum theory relates the energy of an electromagnetic wave to its wavelength or frequency.

E = hν ……..(1)

E = mc^2……..(2)

As the smaller particle exhibits dual nature, and energy being the same, de Broglie equated both these relations for the particle moving with velocity 'v' as,

E =

$$= \frac{hc}{\lambda} = mv^2 :$$

Then,

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

or

$$\lambda = \frac{h}{mv} = \frac{h}{\text{momentum}} :$$

where 'h' is the Plank's constant.

This equation relating the momentum of a particle with its wavelength is de Broglie equation and the wavelength calculated using this relation is the de Broglie wavelength.

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10. **Answer: 4 - 4**

Explanation:

Explanation:
Given:Velocity of the electron , v = 1.5 × 10^8 m/sVelocity of the photon , c = 3 × 10^8 m/sde Broglie wavelength of the electron is equal to that of a photon, i.e. = We have to find the ratio of the energy of the photon and the kinetic energy of the electron.From the given values of v and c, we have– = $\frac{3 \times 10^8 \; /}{1.5 \times 10^8 \; /}$ = 2...(i)de Broglie wavelength of electron is = — = — ..(ii)Kinetic energy of the electron is = $\frac{1}{2}$ ^{2} = $\frac{1}{2}$( ) = $\frac{}{2}$ ..(iii) [from eq. (ii)]Let be the wavelength of the photon, then energy of the photon is = = — ...(iv)where, = —From eqs. (iii) and (iv), we have – = $\frac{/}{/2}$ = (–)($\frac{2}{}$)Using eq. (i), we get – = 2 × 2 = 4 [given, =]Hence, the correct answer is 4.00.