PHYSICS

BOOKS - CHHAYA PHYSICS (BENGALI ENGLISH)

QUANTUM THEORY

Example

1. What is energy of a photoelectron, in electronvolt, moving with a velocity of $2 \times 10^7 ms^{-1}$? (Given, mass of electron $= 9.1 \times 10^{-28} g$)

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2. Stopping potential for a monochromatic light of a metal surface is 4V. What is the maximum kinetic energy of photoelectron

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3. For a metal surface, ratio of the stopping potentials for two different frequencies of incident lights is $1:4$, what is the ratio of the maximum velocities in the two cases?

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4. Find the energy of a photon of wavelength 4950Å in eV ($h = 6.62 \times 10^{-27}$ erg.s) . What is the momentum of this photon?

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5. Find the number of photons emitted per second by a source of power 25W. Assume, wavelength of emitted light $= 6000\text{Å}.\ h = 6.62 \times 10^{-34} J.\ s$

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6. Wavelength of ultraviolet light is $3 \times 10^{-5} cm$. What will be the energy of a photon of this light, in eV? $\left(c = 3 \times 10^{10} m.\ s^{-1}\right)$

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7. Work functions of three metals A, B and C are 1.92 eV, 2.0 eV and 5. eV respectively. Which metal will emit photoelectrons when a light of wavelength 4100Å is incident on the metal surfaces?

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8. In a microwave over the electromagnetic waves are generated having wavelength of the order of 1 cm. Find the energy of the microwave photon. $(h = 6.33 \times 10^{-34} J.\ s)$.

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9. Work functions for zinc is 3.6 eV. If threshold frequency for zinc is 9×10^{14} cps, determine the value of Planck's constant. ($1eV = 1.6 \times 10^{-12}$erg)

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10. Maximum kinetic energy of the released photoelectrons emitted from metallic sodium, when a light is incident on it, 0.73 eV. If the work function of sodium is 1.82eV, find the energy of the incident photon in eV. Find wavelength of incident light.

$(h = 6.63 \times 10^{-27}$ erg. s, $1eV = 1.6 \times 10^{-12}$erg)

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11. Light of wavelength 6000Å is incident on a metal. To release an electron from the metal surface, 1.77 eV of energy is needed. Find the kinetic energy of the fastest photoelectron. What is the threshold frequency of the metal? $\left(h = 6.62 \times 10^{-27} \text{ erg. } s, 1eV = 1.6 \times 10^{-12} \text{ erg}\right)$

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12. Photoelectric threshold wavelength for a metal is 3800Å. Find the maximum kinetic energy of emitted photoelectron, when ultraviolet radiation of wave length 2000Å is incident on the metal surface. Planck's constant, $h = 6.62 \times 10^{-34} J. s$

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13. Threshold wavelength for photoelectric emission from a metal surface is 3800Å, Utraviolet light of wave-length 2600Å is incident on the metal surface.

Find the work function of the metal and

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14. Threshold wavelength for photoelectric emission from a metal surface is 3800Å, Utraviolet light of wave-length 2600Å is incident on the metal surface.

maximum kinetic energy of emitted photoelectron. $\left(h = 6.63 \times 10^{-27} \text{ erg.s}\right)$

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15. When radiation of wavelength 4940Å is incident on a metal surface photoelectricity is generated. For a potential difference 0.6 V between cathode and anode, photocurrent stops. For another incident radiation, the stopping potential changes to 1.1V. Find work function of the metal and wavelength of the second radiation. $\left(h = 6.6 \times 10^{-27} \text{ erg. } s, e = 1.6 \times 10^{-19} C\right)$

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16. A stream of photons of energy 10.6 eV and intensity $2.0 W m^{-2}$ is incident on a platinum surface. Area of the surface is $1.0 \times 10^{-4} m^2$ and its work function is 5.6 eV. 0.53 % of incident photons emit photoelectrons. Find the number of photoelectrons emitted per second and maximum and minimum energies of the emitted photoelectrons in eV. $\left(1 eV = 1.6 \times 10^{-19} J\right)$

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17. At what temperature would the kinetic energy of a gas molecule be equal to the energy of photon of wavelength 6000Å? Given, Boltzmann's constant, $k = 1.38 \times 10^{-23} J.\,K^{-1}$, Planck's constant, $h = 6.625 \times 10^{-34} J.\,s$

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18. Ratio of the work functions of two metal surface is $1:2$. If threshold wavelength of photoelectric effect for the 1st metal is 6000Å, what is the corresponding value for the 2nd metal surface?

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19. Work function of a metal surface is 2eV. Maximum kinetic energy of photoelectrons emitted from the surface for incidence of light of wavelength 4140Å is 1eV. What is the threshold wavelength of radiation for that surface?

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20. Work function of a metal is 4.0 eV. Find the maximum value of wavelength of a radiation that can emit photoelectrons from the metal.

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21. The maximum energies of photoelectrons emitted by a metal are E_1 and E_2 when the incident radiation has frequencies f_1 and f_2 respectively. Show that Planck's constant h and the work function W_0 of the metal are

$$h = \frac{E_1 - E_2}{f_1 - f_2}, W_0 = \frac{E_1 f_2 - E_2 f_1}{f_1 - f_2}$$

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22. A photoelectric source is illuminated successively by monochromatic light of wavelenth λ and $\frac{\lambda}{2}$. Calculate the work function of material of the source if the maximum kinetic energy of the emitted photoelectrons in the second case is 3 times that in the first case.

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23. What is the de Broglie wavelength related to an electron of energy 100 eV ? (Given, mass of electron, $m = 9.1 \times 10^{-31} kg$, $e = 1.6 \times 10^{-19} C$ and $h = 6.63 \times 10^{-34} J.s$)

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24. Calculate the momentum of a photon of frequency $5 \times 10^{13} Hz$ .Given, $h = 6.6 \times 10^{-34} J. s$ and $c = 3 \times 10^{8} m. s^{-1}$

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25. The wavelength λ of a photon and the de Broglie wavelength of an electron have the same value. Show that the energy of the photon is $\frac{2\lambda mc}{h}$ times of the kinetic energy of the electron. Here m, c and h have their usual meaning.

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26. An electron and a photon have same de Broglie wavelength $\lambda = 10^{-1} m$. Compare the kinetic energy of the electron with the total energy of the photon.

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27. Calculate the de Broglie wavelength of an electron of kinetic energy 500 eV.

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28. Find de Broglie wavelength of neutron at $127^{\circ} C$ Given, Boltzmann constant, $k = 1.38 \times 10^{-23} J.\, mol^{-1}.\, K^{-1}$, Planck's constant, $h = 6.626 \times 10^{-34} J.\, s$, mass of neutron, $m = 1.66 \times 10^{-27} kg$

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29. Under what potential difference should an electron be accelerated to obtain electron waves of $\lambda = 0.6\text{Å}$? Given, mass of electron, $m = 9.1 \times 10^{-31} kg$, Planck's constant, $h = 6.62 \times 10^{-34} J. s$

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30. An α-particle and a proton are accelerated from rest through the same potential difference V. Find the ratio of de Broglie wavelengths associated with them.

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31. For what kinetic energy of neutron will the associated de Broglie wavelength be $1.40 \times 10^{-10} m$? The mass of neutron is $1.675 \times 10^{-27} kg$ and $h = 6.63 \times 10^{-34} J. s$

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32. Find the wavelength of an electron having kinetic energy 10 eV.

$\left(h = 6.33 \times 10^{-34} J.\ s, m_e = 9 \times 10^{-31} kg\right)$

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33. An α-particle moves in a circular path of radius 0.83 cm in the presence of a magnetic field of $0.25 Wb / m^2$. What is the de Broglie wavelength associated with the particle?

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Section Related Question

1. What is photoelectric effect

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2. What do you mean by photoelectric work function?

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3. Define: (i) photoelectron and (ii) photoelectric current

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4. What is 'stopping potential' ? Explain

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5. What is threshold frequency in photoelectric emission?

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6. Write down four characteristics of photoelectric effect

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7. State the features of photoelectric effect

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8. What is a photoelectric cell?

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9. Discuss two uses of photoelectric cells

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10. State the laws of photoelectric effect

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11. Write down Einstein's photoelectric equation explaining the symbols used.

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12. Discuss whether wave theory of radiation can explain photoelectric effect or not.

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13. What do you mean by wave particle duality?

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14. What do you mean by matter wave?

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15. Write down the Broglie's hypothesis

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16. What do you mean by de Broglie wavelength?

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17. Determine de Broglie wavelength of an electron accelerated through a potential difference of V volt.

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18. Show that the de Broglie wavelength of electron of energy K is given by $\lambda = \frac{h}{\sqrt{2mK}}$.

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Higher Order Thinking Skill Hots Questions

1. Photoelectric current still continues when the anode is even at a slight negative potential with respect to the photo cathode. Explain.

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2. When radiation of wavelength 2000Å is incident on a nickel plate, the plate gets positively charged. But when wavelength of incident radiation is raised to 3440Å, the plate remains neutral. Explain.

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3. Give example of production of (i) electron by a photon and (ii) photon by an electron

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4. A metal plate that emit photoelectrons under the influence of blue light, may not emit photoelectrons under the influence of red light. Explain

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5. Radiation of frequency $10^{15} Hz$ is incident separately on two photosensitive surfaces P and Q. The following observations were made:

(i) surface P: Photoemission occurs but the photoelectrons have zero kinetic energy

(ii) surface Q: Photoemission occurs and electrons have non-zero kinetic energy.

Which of these two has higher work function? If the frequency of incident light is reduced, what will happen to photoelectron emission in the two cases?

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6. An electron (charge = e, mass = m) is accelerated from rest through a potential difference of V volt. What will be the de Broglie wavelength of the electron?

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7. When light incident on a metal has energy less than the work function of the metal, then no electron is emiited from the surface of the metal. Mathematically justify this statement.

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8. Kinetic energy of proton is the same as that of an α-particle. What is the ratio of their respective de Brogile wavelengths?

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9. What should be the percentage increase or decrease of kinetic energy of an electron so that its de Broglie wavelength is halved?

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10. Kinetic energy of a free electron is doubled. By how many times, would its de Broglie wavelength increase?

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11. Energy of a photon = E , kinetic energy of a proton is also the same as energy of the photon. Corresponding wavelength of the photon and de Broglie wavelength of the proton are λ_1 and λ_2, respectively. What is the relation between E and the ratio of λ_1 and λ_2?

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12. Is matter wave an electromagnetic wave?

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13. Distinguish between matter wave and light wave.

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14. Maximum kinetic energies of photoelectrons emitted from a metal surface when illuminated by radiations of wavelengths λ_1 and λ_2, are K_1 and K_2, respectively. If $\lambda_1 = 3\lambda_2$, show that, $K_1 < \frac{K_2}{3}$

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15. A proton and an electron have the same kinetic energy. Which one has large de Broglie wavelength?

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16. A proton and an electron have same de Broglie wavelength. Which one has higher kinetic energy?

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17. A beam of photon of energy 5.0 eV falls on a free metal surface of work function 3.0 eV . As soon as the photoelectrons are emitted, they are removed. But the emission comes to a stop after a while - explain the reasons.

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18. A photon and an electron have same de Broglie wavelength. Which one has greater total energy?

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19. Does the photoelectric emission take place due to incidence of visible light and ultraviolet rays on the surfaces of different types of metal in our everyday experience?

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20. Why the photoectronic emission can not be performed by using X-rays and gamma rays?

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21. What is the relation of de Broglie wavelength of a moving particle with temperature?

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22. Find the expression of de Broglie wavelength of a particle moving with velocity close to the velocity of light.

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23. If the speed of an electron is v and the speed of another particle is 3v, ratio of the de Broglie wavelength of the electron to that of the particle is $\frac{10^4}{8.13}$. Is the particle a proton or an α-particle? Justify your answer.

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24. Prove that the product of the slope of V_0-f graph and electronic charge gives the value of planck's constant.

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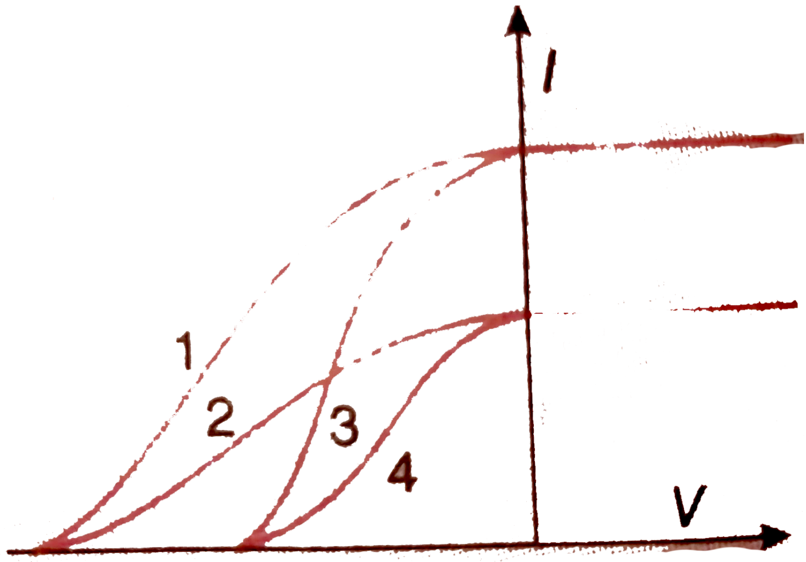
25. The given graphs show the variation of photoelectric current (I) with the applied voltage (V) when light of different instensities is incident on surfaces of different materials. Identify the pairs of curves that correspond to different materials but same intensity of incident radiations.



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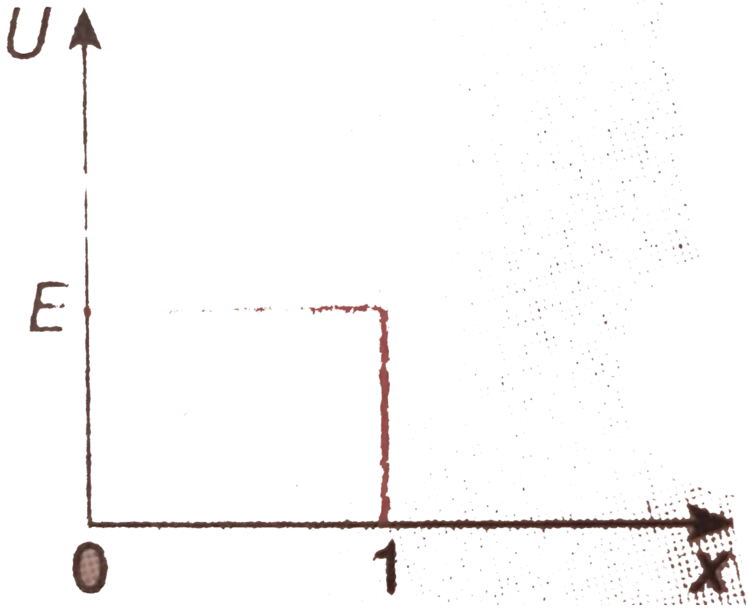
26. The potential energy U of a moving particle of mass m varies with x as shown in figure. The de Broglie wavelengths of the particle in the regions $0 \leq x \leq 1$ and $x > 1$ are λ_1 and λ_2 respectively.

If the total energy of the particle is nE, find $\frac{\lambda_1}{\lambda_2}$



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Ncert Textbook Questions With Answer Hint

1. Monochromatic light of wavelength 632.8 nm is produced by a helium-neon laser. The power emitted is 9.42mW.

Find the energy and momentum of each photon in the light beam.

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2. Monochromatic light of wavelength 632.8 nm is produced by a helium-neon laser. The power emitted is 9.42mW.

How many photonsper second, on the average, arrive at a target irradiated by beam? (Asume the entire beam to be incident on a small area of the target)

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3. Monochromatic light of wavelength 632.8 nm is produced by a helium-neon laser. The power emitted is 9.42mW.

what should be the velocity of a hydrogen atom in order to have the same momentum of photon?

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

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

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6. The work function for a certain metal is 4.2 eV. Will this metal give photoelectric emission for incident radiation of wavelenght 330 nm?

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7. Light of wavelength 488 nm is produced by an argon laser which is used in the photoelectric effect. When light from this spectral line is incident on the cathode, the stopping (cut-off) potential of photo electrons is 0.38 V. Find the work function of the material from which the cathode is made.

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

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9. What is the de broglie wavelength of a bullet of mass 0.040 kg travelling at the speed of $1.0km.\ s^{-1}$?

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10. The wavelength of each of a photon and an electron is 1.00 nm. Find their (a) momentum and (b) energy.

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11. The average kinetic energy of a neutron at 300 K is $\frac{3}{2}$kT. Find its de Broglie wavelength.

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12. What is the de Broglie wavelength of anitrogen molecule at 300 K? Assume the molecule to be moving with its rms speed. [Atomic mass of nitrogen = 14.0076 u]

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13. In an accelerator experiment on high energy collisions of electrons with positrons, a certain event is interpreted as annihilation of an electron-positron pair of total energy 10.2 Gev into two γ-rays of equal energy . What is the wavelength associated with eachγ- rays?(1GeV =$10^9 eV$)

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14. Estimating the following number should be interesting. The number will tell you why radio engineers need not worry much about photons.

The number of photons emitted per second by a medium wave transmitter of 10 kW power, emitting radiowaves of wave-length 500 m.

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15. Estimating the following number should be interesting. The number tells you why our eye can never 'count photons', even in barely detectable light.

The number of photons entering the pupil of our eye per second corresponding to the minimum intensity of white light that we humans can perceive $\left(\sim 10^{-10} W . m^{-2}\right)$. Take the area of the pupil to be about $0.4 cm^2$ and the average frequency of the white light to be about 6×10^{14} Hz.

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16. Monochromatic radiation of wavelength 640.2 nmY from a neon lamp irradiates photosensitive material made of calcium or tongusten. The stopping votage is measured to be 0.54V. The source is replaced by an iron source and its 427.2 nm line irradiates the same photo cell. Predict the new stopping voltage.

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17. An electron microscope uses electrons accelerated by a voltage of 50 kV. Determine the de Broglie wavelength associated with he electrons. If other factors (such as numerical aperture etc.) are taken to be roughly the same, how does the resolving power of an electron microscope compare with that of an optical microscope which uses yellow light?

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18. Find the typical de Broglie wavelength associated with a He atom in helium gas at room temperature $(27^\circ C)$ and 1 atm pressure.

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19. Every metal has a definate work function. Why do all photoelectrons not come out with the same energy if incident radiation is monochromatic?

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Ncert Exemplar Questions With Answer Hint

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

A. H

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

C. H^{0}

D. $H^{-\frac{1}{2}}$

Answer: D

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

A. no electrons will be emitted as only photons can emit electrons

B. electrons can be emitted but all with an energy E_0

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

D. electrons can be emitted with any energy, with a maximum of E_0

Answer: D

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3. An electron (mass m) with an initial velocity $\vec{V} = v_0 \hat{i} (v_0 > 0)$ is in an electric field $\vec{E} = -E_0 \hat{i}$ (E_0 = constant > 0). Its de Broglie wavelength at time t is given by

A. $\dfrac{\lambda_0}{\left(1 + \frac{eE_0}{m} . \frac{t}{v_0}\right)}$

B. $\lambda_0 = \left(1 + \dfrac{eE_0 t}{m v_0}\right)$

C. λ_0

D. $\lambda_0 t$

Answer: A

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4. An electron (mass m) with an initial velocity $\overrightarrow{V} = v_0 \hat{i}$ is in an electric field $\overrightarrow{E} = E_0 \hat{j}$. If $\lambda_0 = \frac{h}{mv_0}$, its de Broglie wavelength at time t is given by

A. λ_0

B. $\lambda_0 \sqrt{1 + \frac{e^2 E_0^2 t^2}{m_0^2 v_0^2}}$

C. $\frac{\lambda_0}{\sqrt{1 + \frac{e^2 E_0^2 t^2}{m_0^2 v_0^2}}}$

D. $\frac{\lambda_0}{\left(1 + \frac{e^2 E_0^2 t^2}{m_0^2 v_0^2}\right)}$

Answer: C

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5. An electron is moving with an initial velocity $\overrightarrow{V} = v_0\hat{i}$ and is in a magnetic field $\overrightarrow{B} = B_0\hat{j}$. Then its de Broglie wavelength

A. remains constant

B. increases with time

C. decreases with time

D. increases and decreases periodically

Answer:

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6. Relativistic corrections become necessary when the expression for kinetic energy $\frac{1}{2}mv^2$ becomes comparable to mc^2. At what de

Broglie wavelength will relativistic corrections become important for an electron?

A. 10nm

B. $10^{-1} nm$

C. $10^{-4} nm$

D. $10^{-6} nm$

Answer: C::D

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7. Photons absorbed in matter are converted to heat. A source emitting n photons/s of frequency f is used to convert 1 kg of ice at $0.^{\circ} C$ to water at $0.^{\circ} C$. Then the time T taken for the conversion

A. decreases with increasing n, with f fixed

B. decreases with n fixed, f increasing

C. remains constant with n and f changing such that nf = constant

D. increases when product nf increases.

Answer: A::B::C

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

A. The particle could be moving in a circular orbit with origin as centre

B. The particle could be moving in an elliptic orbit with origin as focus

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

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

Answer: B::D

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Exercise Multiple Choice Questions

1. A monochromatic source of light is kept at a distance of 0.2 m from a photoelectric cell. Stopping potential V_0 and saturation current I_0 are 0.6 V and 18.0 mA, respectively. Now the source is kept at a distance of 0.6 m from the cell. Then

A. $V_0 = 0.2V, I_0 = 18.0mA$

B. $V_0 = 0.2V, I_0 = 2.0mA$

C. $V_0 = 0.6V, I_0 = 18.0mA$

D. $V_0 = 0.6V, I_0 = 2.0mA$

Answer: D

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2. For a monochromatic light incident on a metal surface, the stopping potential is V. Then the kinetic energy of the fastest photoelectrons emitted from that surface is

A. eV

B. 2eV

C. $\frac{2eV}{m}$

D. $\sqrt{\frac{2eV}{m}}$

Answer: A

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3. If in a photo-electric experiment, the wavelength of incident radiation is reduced from $6000\text{Å} \text{ to } 4000\text{Å}$ then

A. stopping potential will decrease

B. stopping potential will increase

C. kinetic energy of emitted electrons will decrease

D. the value of work function will decrease

Answer: B

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4. If the stopping potential for photoelectric emission is 0.75 V, the kinetic energy of the fastest photoelectrons is

A. 0.75 V

B. 7.5 eV

C. 0.75 eV

D. $0.75 \times 10^{-19} J$

Answer: C

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5. For a monochromatic light incident on a metal surface, the maximum velocity of the emitted photoelectrons is v. Then the stopping potential would be

A. $\frac{2mv^2}{e}$

B. $\frac{mv^2}{e}$

C. $\frac{mv^2}{2e}$

D. $\frac{mv^2}{\sqrt{2}e}$

Answer: C

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6. For two monochromatic radiations incident on the same metal surface, the stopping potentials are 1.0 V and 2.0 V. The ratio between the maximum velocities, of the emitted photoelectrons is

A. $2:1$

B. $\sqrt{2}:1$

C. $1 : \sqrt{2}$

D. $1 : 2$

Answer: C

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7. Energy of photon incident on a metal plate is twice its work function. How many times should be the wavelength of incident light so that the kinetic energy of the fastest electron will be doubled?

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

B. $\frac{2}{3}$ times

C. $\frac{1}{2}$ times

D. 2 times

Answer: B

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8. Work function of zinc is twice that of sodium. If the photoelectric threshold wavelength for sodium is 7000Å, what will be its vaue for zinc?

A. 3500Å

B. 14000Å

C. 10500Å

D. 4667Å

Answer: A

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9. Threshold wavelength of a metal for electron emission is $5200 Å$. Which one of the following sources of light will be able to emit electrons from the metal?

A. 50 W infrared

B. 1 W infrared

C. 50 W red light

D. 1 W ultraviolet

Answer: D

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10. When photons of energy 6eV is incident on a metal surface, the kinetic energy of the fastest electrons becomes 4eV. The value of stopping potential is (in V)

A. 2

B. 4

C. 6

D. 10

Answer: B

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11. In case of photoelectric effect, the incident photon

A. vanishes completely

B. is scattered with lower frequency

C. is scattered with higher frequency

D. is scattered with the same frequency

Answer: A

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12. Which of the following quantities has the same dimension as that of Planck's constant?

A. linear momentum

B. angular momentum

C. energy

D. power

Answer: B

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13. In case of photoelectric effect, the graph of kinetic energy of photoelectron with respect to the frequency of incident radiation will be a straight line. The slope of this straight line depends on

A. the nature of the metal surface

B. the intensity of the incident radiation

C. the nature of the metal surface as well as the intensity of incident radiation

D. none of the nature of the metal surface or the intensity of incident radiation

Answer: D

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14. A body absorbs 5×10^{29} photons of frequency 10^{20} Hz. Which of the following information is correct? [Assume, all the energy of photons is transformed into mass]

A. mass of the body remains unchanged

B. mass of the body increases by 0.00037 kg

C. mass of the body increases by 0.37 kg

D. mass of the body increases by 3.7 kg

Answer: C

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15. The momentum of a photon (frequency = f, rest mass = 0) is

A. $\frac{hf}{c}$

B. $\frac{h\lambda}{c}$

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

D. zero

Answer: A

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16. A monochromatic radiation of wavelength λ and intensity I is incident on a plate of area A. Find the number of photons striking the plate per second.

A. $\frac{I\lambda}{Ahc}$

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

C. $\frac{I\lambda A}{hc}$

D. $\frac{h\lambda}{c\lambda A}$

Answer: C

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17. The threshold frequency for a photosensitive metal is $3.3 \times 10^{14} Hz$. If a light of frequency $8.2 \times 10^{14} Hz$ is incident on this metal, the cut-off voltage for the photoelectron emission is nearly.

A. 1V

B. 2V

C. 3V

D. 5V

Answer: B

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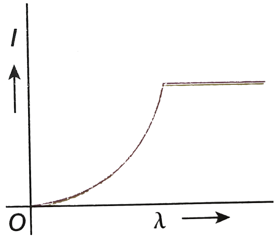
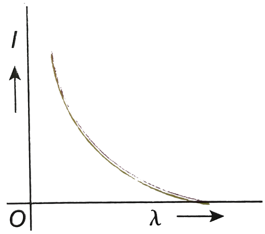
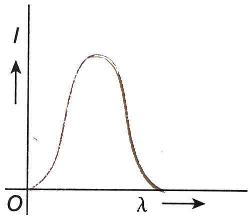
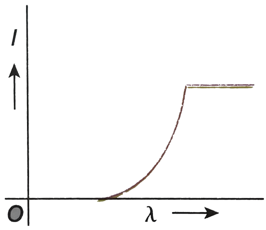
18. The anode voltage of a photocell is kept fixed. The wavelength λ of the light falling on the cathode is gradully changed. The plate current I of the photocell varies as follows.

A. 

B. 

C. 

D. 

Answer: B

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19. A body of mass 60g is moving with a velocity of $10m. s^{-1}$. The de Broglie wavelength of the body will be approximately $(h = 6.63 \times 10^{-34} J. s)$

A. $10^{-35} m$

B. $10^{-25} m$

C. $10^{-33} m$

D. $10^{-23} m$

Answer: C

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20. If the de Broglie wavelength of a gas molecule at $0^\circ C$ be λ, what will be its wavelength at $819^\circ C$?

A. λ

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

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

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

Answer: B

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21. Two moving electrons have a ratio of $1:2$ between their respective kinetic energies. The ratio between their de Broglie wavelength is

A. $2:1$

B. $\sqrt{2}:1$

C. $1:\sqrt{2}$

D. $1:2$

Answer: B

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22. An electron is accelerated by a photentential difference V and as a result, its de Broglie wavelength beocmes λ. If the applied potential difference was 2V, the de Broglie wavelength would have been

A. 2λ

B. $\sqrt{2}\lambda$

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

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

Answer: C

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23. The wavelength associated with an electron of mass m having kinetic energy E is given by

A. $\frac{2h}{mE}$

B. 2mhE

C. $\frac{2\sqrt{2mE}}{h}$

D. $\frac{h}{\sqrt{2mE}}$

Answer: D

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24. The wavelength of a light is 0.01Å. If h be the Planck's constant, then the momentum of the corresponding photon will be

A. $10^{-2}h$

B. h

C. $10^2 h$

D. $10^{12} h$

Answer: D

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

A. increase by 2 times

B. decrease by 2 times

C. decrease by 4 times

D. increase by 4 times

Answer: B

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

A. $100p_0$

B. $\frac{p_0}{400}$

C. $401p_0$

D. $\frac{p_0}{100}$

Answer: C

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27. The proton when accelerated through a potential difference of V volt has a wavelength λ associated with it. If an α-particle is to have the same wavelength λ, it must be accelerated through a potential difference of

A. $\frac{V}{8}$

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

C. 4V

D. 8V

Answer: A

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Exercise Very Short Answer Types Questions

1. Below a minimum frequency of light, photoelectric emission does not occurs. Is the statement true or false?

Watch Video Solution

2. Above the threshold wavelength for a metal surface, even a light of low intensity can emit photoelctrons. Is the statement true?

Watch Video Solution

3. What will be the effect on the velocity of emitted photo-electron if the wavelength of incident light is gradually decreased?

Watch Video Solution

4. Why are alkali metals highly photon-sensitive?

Watch Video Solution

5. Express in eV the amount of kinetic energy gained by an electron when it is passed through a potential difference of 100 V.

Watch Video Solution

6. Photoelectric threshold wavelength for a metal is 2100Å. If the wavelength of incident radiation be 1800Å, will there be any emission of photoelectrons?

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7. Which property of photoelectric particles was discovered from Hertz's experiment?

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8. Which property of photoelectric particles was measured from Lenard's experiment?

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9. What is the relation between the stopping potential V_0 and the maximum velocity $v_{\max}$ of photoelectrons?

Watch Video Solution

10. How does the kinetic energy of photoelectrons change due to increase in intensity of incident light?

Watch Video Solution

11. Give an example of production of photons by electrons.

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12. Maximum kinetic energy of photoelectrons depends on the _____ of light used, but does not depend on the _____ of light

Watch Video Solution

13. In case of photoelectric emission, the maximum kinetic energy of photoelectrons increases with increase in the _____ of incident light

Watch Video Solution

14. Lenard concluded from his experiment that the particles emitted in photoelectric effect are ____

View Text Solution

15. Given an example of production of electrons by photons

Watch Video Solution

16. If the intensity of incident radiation on a metal surface is doubled, what happens to the kinetic energy of the electrons emitted?

Watch Video Solution

17. Write down the relation between threshold frequency and photoelectric work function for a metal.

Watch Video Solution

18. Which property of light is used to explain the characteristics of photoelectric effect?

Watch Video Solution

19. What is the rest mass of a photons?

Watch Video Solution

20. The wavelength of an electromagnetic radiation is λ. What is the energy of a photon of this radiation?

Watch Video Solution

21. The light coming from a hydrogen-filled discharge tube falls on sodium metal. The work function of sodium is 1.82 eV and the kinetic energy of the fastest photoelectron is 0.73 eV. Find the energy of incident light

Watch Video Solution

22. In case of photoelectric emission, the maximum kinetic energy of emitted electrons depends linearly on the ______ of incident radiation

Watch Video Solution

23. In case of electromagnetic radiation of frequency f, what is the momentum of the associated photon?

Watch Video Solution

24. If photons of energy 6eV are incident on a metallic surface, the kinetic energy of fastest electrons becomes 4eV. What is the value of the stopping potential?

Watch Video Solution

25. The threshold wavelength of a metal having work function W is λ. What will be the threshold wavelength of a metal having work function 2W ?

Watch Video Solution

26. The work function of a metal surface for electron emission is W. What will be the threshold frequency of incident radiation for photoelectric emission?

Watch Video Solution

27. What is the effect on the velocity of the emitted photoelectrons if the wavelength of the incident light is decreased?

Watch Video Solution

28. Two metals A and B have work function 4eV and 10eV respectively. Which metal has higher threshold wavelength?

Watch Video Solution

29. Ultravilet light is incident on two photosensitive materials having work functions W_1 and $W_2 (W_1 > W_2)$. In which case will the kinetic energy of the emitted electrons be greater? Why?

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30. Is it possible to bring about interference of electron?

Watch Video Solution

31. What type of wave is suitable to represent the wave associated with a moving particle?

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32. Davission and Germer experimentally demonstrated the existence of _____ waves

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33. The wavelength of a stream of charged particles accelerated by a voltage V is λ. What will be the wavelength if the voltage is increased to 4V?

Watch Video Solution

34. The de Broglie wavelength of an electron and the wavelength of a photon are equal and its value is $\lambda = 10^{-10} m$. Which one has a higher kinetic energy?

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35. An electron and a proton have the same kinetic energy. Identify the particle whose de Broglie wavelength would be greater

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36. The de Broglie wavelength of a particle of kinetic energy K is λ. What would be the wavelength of the particle if its kinetic energy were K/4 ?

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

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Exercise Short Answer Type Questions I

1. If the anode of a photoelecric cell is given a slightly negative potential with respect to the cathode, even then the cell works. Explain.

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2. Photoelectric effect is the opposite phenomenon of X-ray emission'. Explain.

Watch Video Solution

3. In spite of being a massless particle, a photon has some momentum-explain.

Watch Video Solution

4. An electron and a proton have the same de Broglie wavelength. Which one has higher kinetic energy?

Watch Video Solution

5. Why can a matter wave not be represented by a pure sinusoidal wave?

Watch Video Solution

6. An electron of charge e and mass m is acceleration from rest with a potential V. What is the de Broglie wavelength of the electron?

Watch Video Solution

7. A strong red ligh cannot be emit photoelectrons from a metal surface, yet a feeble ultraviolet radiation can - explain how it is possible.

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8. A metal surface does not emit any electron if the energy of incident radiation is less than the photoelectric work function of the metal - justify the statement mathematically.

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9. The de broglie wavelength of a moving electron is physically important quality, but that of a moving cricket ball has no pertical significance - why?

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10. The frequerncy of incident radiation is greater than threshold frequency in a photocell. How will the stopping potential vary, if frequency is increased, keeping other factors constant?

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11. If the frequency of incident radiation on a photocell is doubled for the same intensity, what changes will you observe in (i) kinetic energy of photoelectrons emitted (ii) photoelectric current?

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12. Show that the de Broglie wavelength of charged particles accelerated through a potential of V volt is given by $\lambda = h / \sqrt{2mqV}$. Hence show that the de-Broglie wavelength of electron is $\frac{12.27}{\sqrt{V}}$Å .

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13. A source of light is placed at a distance of 50cm from a photocell and the cutt-off potential is found to be V_0. If the distance between the light source and the photocell is made 25cm, what will be the new cutt-off potential? Justify your answer.

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14. How does (i) photoelectric current and (ii) kineic energy of the photoelectrons emitted in a photocell vary if the intensity of the incident radiation is doubled?

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15. Does the 'stopping potential' in photoelectric emission depend upon (i) the intensity of the incident radiation in a photocell? (ii) the frequency of the incident radiation?

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16. Explain the effect of increase of (i) frequency (ii) intensity of the incident radiation on photoelectrons emitted by a phototube.

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17. For a photosensitive surface, threshold wavelength is λ_0. Does photoemission occur, if the wavelength (λ) of the incident radiation is (a) more than λ_0 (b) less than λ_0? Justify your answer.

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18. An electron and a proton are moving in the same direction and posses same kinetic energies. Find the ratio of de Broglie wavelength associated with these particles.

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Exercise Short Answer Type Questions Ii

1. A beam of photons of energy 5.0 eV is incident on a metal surface, whose work function is 3.0 eV. The metal remains isolated and the photoelectrons are being removed instantaneously after their emission. Although photoelectric emission akes places initially, but after some times it ceases. Explain it with reasons.

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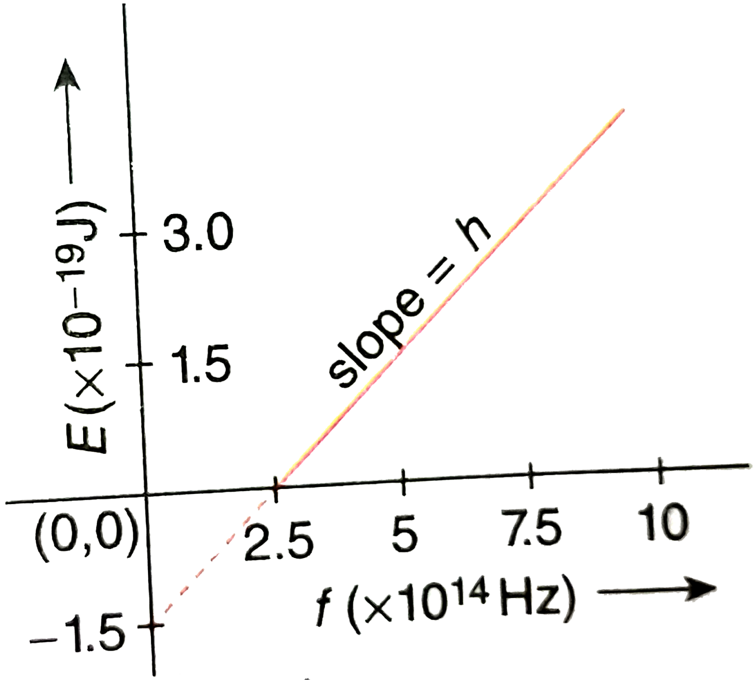
2. In an experiment of photoelectric effect, the variation of maximum kinetic enegy (E) of the emitted electrons with frequency has been shown in Fig. 1.19. From the figure, determine (i) threshold frequecy, (ii) work function, (iii) Planck's constant.



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3. An electromagnetic wave of wavelength λ is incident on a photoelectrons emitted from this surface have the de Broglie wavelength λ_1 prove that $\lambda = \left(\frac{2mc}{h}\right)\lambda_1^2$

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

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Exercise Problem Set I

1. For a monochromatic radiation incident on a metal surface, the stopping potential is 2.0V. Find out the maximum velocity of the emitted photoelectrons.

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2. For a monochromatic radiation incident on the metal surface, the photoelectrons are emitted with a maximum velocity of $10^6 m. s^{-1}$. What will be the stopping potential?

Watch Video Solution

3. The wavelength of an ultraviolet radiation is $3 \times 10^{-5} cm$. What is the energy, in eV, of the associated photon? $(c = 3 \times 10^{10} cm. s^{-1})$

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4. A photon has an energy of 75eV. Find its frequency and momentum.

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5. Wavelength of some X-ray is 1Å. Determine the energy of the X-ray photon.

Watch Video Solution

6. The photon energy of a radiation is 2.55eV. Determine the frequency and wavelength of that radiation.

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7. How many photons will a source of power 50W produce per second? The wavelength of an emitted photon is 6000 Å . Given , $h = 6.62 \times 10^{-34} J.s$

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8. A red line in the hydrogen spectrum has a wavelength of 6563 Å. Find out its photon energy.

Watch Video Solution

9. The photon energy of a radiation is 1keV. What will be its (i) frequency, and (ii) wavelength?

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10. The photon energy corresponding to a radiation of wavelength 5000 Å is 2.48eV. Find out Planck's constant from this data.

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11. Work function for monlybdenum is 4.2 eV. Determine the threshold wavelength of photoelectric effect for molybdenum.

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12. Work function for a metal is 1.77 eV and the wavelength of an incident ray on that metal is 5893 Å. Determine the maximum kinetic energy of the photoelectrons emitted from that metal.

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13. Energy of incident photon on a metal surface is 5.0 eV and photoelectric stopping potential is 3.23V. Determine the threshold wavelength for the metal.

Watch Video Solution

14. thresold Wavelength of incident light on a metal surface is 404 Å. Determine the work function.

Watch Video Solution

15. Stopping poential for the electrons emitted due to incidence of light on a metal is 3V. Determine the frequency of this light and also the work function for metal. Given, the threshold frequency for photoelectric emission from that metal is $6 \times 10^{14} Hz$.

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16. For photoelectric emission, threshold wavelength of a metal is 2460 Å. If ultraviolet light of wavelength 1810 Å be incident on the metal, what will be the maximum kinetic energy of the emitted electrons? [Planck's constant $= 6.62 \times 10^{-34} J. s$, velocity of light in veccuum $= 3 \times 10^{8} m. s^{-1}$]

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17. The stopping potential of copper is 2.72V for light of wavelength 1849 Å. Determine the work function and threshold frequency of the metal.

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18. When radiation of wavelength λ is incidenton a metallic surface, the stopping potential is 4.8V. If the same surface is illuminated with radiation of double the wavelength, the stopping potential becomes 1.6V. What is the threshold wavelength for the surface?

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19. work function for electronic emission from sodium is 1.77 eV. What is the threshold frequency of incident radiation for photon-emission from sodium?

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20. The work function for electron emission from a metal is 1.9 eV, and the wavelength of the radiation incident on its surface is 4041 Å. Find out the kinetic energy of the fastest photoelectrons.

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21. The photoelectric threshold wavelength of radiation incident on its surface is 3415Å. If the wavelength of radiation incident on its surface 2020 Å, find out the (i) work function and (ii) kinetic energy of the fastest photoelectrons.

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22. The photoelectric work function of a metal is 1.2 eV. What will be the stopping potential for a radiation of wavelength 5500Å incident on its surface?

Watch Video Solution

23. The photoelectric work function of a metal is 3800 Å. If an ultraviolet radiation of wavelength 2000 Å is incident on its surface, find out the maximum kinetic energy of the emitted photoelectrons. (Planck's constant $= 6.63 \times 10^{-34} J. s$).

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24. Find out the photoelectric threshold wavelength of copper. Given work function of copper $= 4.52 eV, h = 6.6 \times 10^{-34} J.s, 1 eV = 1.6 \times 10^{-19} J$

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25. Find the photoelectric threshold frequency of a metal is 6525 Å. What will be the stopping potential if the metal is irradiated with light of wavelength 4000 Å?

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26. A monochromatic source, emitting light of wavelength, 600 nm, has a power output of 66W. Calculate the number of photons emitted by this source is 2 minutes.

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

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28. By how much would the stopping potential for given photosensitive surface go up if the frequency of the incident radiations were to be increased from $4 \times 10^{15} Hz$ to $8 \times 10^{15} Hz$? Given

$h = 6.4 \times 10^{-34} J.\ s, e = 1.6 \times 10^{-19} C$ and $c = 3 \times 10^{8} m.\ s^{-1}$.

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29. Calculate the threshold frequency of photon for photoelectric emission from a metal of work function 0.1eV.

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30. Calculate the kinetic energy of photoelectrons in eV emitted on shining light of wavelength $6.2 \times 10^{-8}m$ on a metal surface. The work fuction of metal is 0.1eV. Given: $h = 6.6 \times 10^{-34} J. s.$

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31. Calculate the maximum kinetic energy of electrons emitted from a photosensitive surface of work function 3.2eV, for the incident radiation of wavelength 300nm.

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32. The de Broglie wavelength associated with a moving particle changes from 0.2Å to 0.4Å. Determine the change in momentum of the particle. $(h = 6.63 \times 10^{-34} J.s)$.

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33. Determine the de Broglie wavelength of an electron moving with velocity $10^6 m.s^{-1}$. What will be the de Broglie wavelength of a proton, moving with the same velocity? Given, Planck's constant $= 6.62 \times 10^{-34} J.s$, mass of electron $= 9.1 \times 10^{-31} kg$, mass of proton is 1840 times that of an electron.

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34. For a moving electron, the de Broglie wavelength is 1 Å. What will be the de Broglie wavelength if (i) the momentum of electron be doubled, (ii) the kinetic energy of the electron be doubled?

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35. If an electron is send through a potential difference of 60V, what will be the wavelength associated with it?

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36. The de Broglie wavelength of a moving electron is 1 $\mathring{A}$. What is its velocity?

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37. A neutron of mass $1.66 \times 10^{-27} kg$ has a kinetic energy of 0.04eV. What is its de Broglie wavelength?

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38. What is the de Broglie wavelength of an α-particle moving with a velocity of $1.635 \times 10^3 m. s^{-1}$? Given, mass of a α-particle $= 6.65 \times 10^{-27} kg.$

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39. What will be the de Broglie wavelength of an electron of kinetic energy 500eV?

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40. The wavelength associated with a photon and the de Broglie wavelength of a moving electron are equal. If they carry the same amount of energy, what is the value of this wavelength?

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41. Calculate de Broglie wavelength of an electron beam accelerated through a potential difference of 60V.

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Exercise Problem Set Ii

1. The power of a monochromatic light of frequency $6 \times 10^{14} Hz$ is $2 \times 10^{-3} W$

What is the energy of photon in the light beam?

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2. The power of a monochromatic light of frequency $6 \times 10^{14} Hz$ is $2 \times 10^{-3} W$

On average, how many photons are emitted by the source? Given, $h = 6.63 \times 10^{-34} J.s$

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3. Work function of sodium is 2.3 eV. Find out the energy of photon of the orange light of sodium. Does sodium show photoelectric emission for orange light of wavelength, $\lambda = 6800 Å$? Given, $h = 6.63 \times 10^{-34} J.s$

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4. When light of wavelength $4041 Å$ falls on a metal surface, the maximum velocity of the emitted photoelectrons becomes twice the maximum velocity when another light of wavelength $5893 Å$ falls on the same surface. What is the photoelectric work function of that metal?

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5. A stream of photons having energy 3.07 eV is incident on a metal plate of area $1cm^2$ with an intensity of $1W.m^{-2}$. If 1% of the incident photons emit photoelectrons, determine the value of saturation current.

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6. Work function of a metal is 2.3eV and on $1.0cm^2$ area of that metal, a light of intensity $8.6 \times 10^3 W.m^{-2}$ is incident. That intensity is distributed equally among the wavelength $4144Å, 4972Å$ and $6216Å$. If no ray is lost due to scattering and if each of the photons of proper energy can emit photoelectrons, what will be the number of photoelectrons emitted in 2 s? $(h = 6.63 \times 10^{-34} J.s, 1eV = 1.6 \times 10^{-19} J)$

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7. Ultraviolet rays of wavelengths 800Å and 700Å fall on a hydrogen atom initially in its minimum energy state. As a result, electrons having energies 1.8 eV and 4.0 eV are emitted. Determine the value of Planck's constant

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8. A metal has a work function of 2eV. It is illuminated by monochromatic light of wavelength 500 nm, calculate (i) the threshold wavelength, (ii) the maximum energy of photoelectrons, (iii) The stopping potential. Given Planck's constant $h = 6.6 \times 10^{-34} J. s$, charge on electron $e = 1.6 \times 10^{-19} C$ and $1eV = 1.6 \times 10^{-19} J$

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9. If the photoelectric threshold wavelength of metallic silver is 3500Å, and UV light of wavelength 2000Å falls on it, find (i) the maximum kinetic energy of the photoelectrons, (ii) the maximum velocity of the photoelectrons, (iii) the value of work function of silver in joule

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10. A 5 W point source emits monochromatic light of wave length 5000Å

How many photons per second strike a unit area placed 5m away from the source and illuminated by it?

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11. A 5 W point source emits monochromatic light of wave length

500Å

What should be the work function of the meal from whose surface this light can liberate photoelectrons?

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

$h = 6.63 \times 10^{-34} J.s$ and $c = 3 \times 10^8 m.s^{-1}$

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13. An electron, an α-particle and a proton have the same kinetic energy. Which of these particles has the shortest de Broglie wavelength?

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14. If wavelength (λ) of a photon and de Broglie wavelength of an electron are same, then show that the energy of the photon is $\frac{2\lambda mc}{h}$ times the kinetic energy of the electron. Here, m, c and h have their usual meanings

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15. An X-ray tube operates at 10 kV. Show that, the ratio of X-ray wavelength to that of de Broglie wavelength is approximately 10

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Exercise Hots Numerical Problems

1. The work function for cesium is 1.8 eV. A light of wavelength 5000Å is incident on it. Calculate (i) maximum kinetic energy of emitted electrons, (ii) threshold frequency and threshold wavelength and (iii) maximum velocity of the emitted electrons

Watch Video Solution

2. Light of wavelength 4000Å is incident on barium. The emitted photoelectrons describe a circle of radius 50 cm by a magnetic field of flux density $5.26 \times 10^{-6}T$. What is the work function of barium in eV? Given, $h = 6.6 \times 10^{-34} J.s, \quad e = 1.6 \times 10^{-19} C, \quad m_e = 9.1 \times 10^{-31} kg$

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3. When a piece of metal is illuminated by monochromatic light of wavelength λ, the stopping potential for photoelectric current is $2.5V_0$. If the same surface is illuminated by light of wavelength 1.5λ, the stopping potential becomes V_0. Find the out the value of threshold wavelength for photoelectric emission.

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4. A particle A with a mass m_A is moving with a velocity v and collides with a particle B of mass $m_B(m_A > M_B)$ at rest (one dimensional motion). Calculate the change in the de Broglie wavelength of the particle A. Assume that the collision is elastic in nature.

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Entrance Corner Assertion Reason Type

1. Statement I: Any light wave having frequency less than $4.8 \times 10^{14} Hz$ cannot emit photoelectrons from a metal surface having work function 2.0 eV

Statement II: If the work function of a metal is W_0 (in eV), then the maximum wavelength (in Å) of the light capable of initiating photoelectric effect in the metal is given by $\lambda_{\max} = \frac{12400}{W_0}$

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I

C. statement I is true, statement II is false

D. statement I is false, statement II is true

Answer: A

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2. Statement I: The energy of the associated photon becomes half when the wavelength of the electromagnetic wave is doubled.

Statement II: Momentum of a photon

$$= \frac{\text{energy of the photon}}{\text{velocity of light}}$$

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I

C. statement I is true, statement II is false

D. statement I is false, statement II is true

Answer: B

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3. Statement I: In photoelectric effect the value of stopping potential is not at all dependent on the wavelength of the incident light.

Statement II: The maximum kinetic energy of the emitted photoelectron and stopping potential are proportional to each other.

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I

C. statement I is true, statement II is false

D. statement I is false, statement II is true

Answer: D

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4. Statement I: The maximum velocity of the photoelectron emitted from a metal surface does not increase even if the intensity of the incident electromagnetic wave is increased.

Statement II: Einstein's photoelectric equation:

$$\frac{1}{2}mv_{\max}^2 = hf - W_0$$

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I

C. statement I is true, statement II is false

D. statement I is false, statement II is true

Answer: A

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5. Statement I: The stopping potential becomes double when the frequency of the incident radiation is doubled

Statement II: Work function of the metal and the threshold frequency of photoelectric effect are proportional to each other.

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I

C. statement I is true, statement II is false

D. statement I is false, statement II is true

Answer: D

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6. Statement I: If the kinetic energy of particles with different masses are same, then the de Broglie wavelength of the particles are inversely proportional to their mass

Statement II: Momentum of moving particles is inversely proportional to their de Broglie wavelengths.

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I

C. statement I is true, statement II is false

D. statement I is false, statement II is true

Answer: D

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7. Statement I: If a stationary electron is accelerated with a potential difference of 1V, its de Broglie wavelength becomes $12.27 \mathring{A}$ approximately.

Statement II: The relation between the de Broglie wavelength λ and the accelerating potential V of an electron is given by $\lambda = \frac{12.27}{V} \mathring{A}$

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I

C. statement I is true, statement II is false

D. statement I is false, statement II is true

Answer: C

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8. Statement I: A moving particle is represented by a progressive wave group.

Statement II: Pure sinusoidal wave cannot represent the instantaneous velocity or position of a moving particle.

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I

C. statement I is true, statement II is false

D. statement I is false, statement II is true

Answer: A

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9. Statement I: The wavelength of 100 eV photon is 124Å

Statement II: The energy of a photon of wavelength λ in Å is

$$E = \frac{12400}{\lambda} eV$$

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I

C. statement I is true, statement II is false

D. statement I is false, statement II is true

Answer: A

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10. Statement I: A proton, a deutron and an α-particle are accelerated by the same potential difference. Their velocities will be in the ratio of $1:1:\sqrt{2}$

Statement II: Kinetic energy, $E = qV = \frac{1}{2}mv^2$

A. Statement I is true, statement II is true, statement II is a correct explanation for statement I

B. Statement I is true, statement II is true, statement II is not a correct explanation for statement I

C. statement I is true, statement II is false

D. statement I is false, statement II is true

Answer: D

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Entrance Corner Multiple Correct Answer Type

1. The threshold frequency of a photoelectric effect depends on

A. nature of the metal surface

B. intensity of the incident radiation

C. energy of incident photon

D. work function of the metal

Answer: A::D

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2. Maximum kinetic energy of photoelectron depends on

A. nature of the metal surface

B. intensity of the incident radiation

C. energy of incident photon

D. work function of the metal

Answer: A::C::D

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3. The work function of a metal surface is 2.0 eV. Light of wavelength 5000Å is incident on it:

A. the energy of each incident photon is 2.48 eV

B. the threshold wavelength for photoelectric effect is 6200Å

C. maximum kinetic energy of emitted photoelectron is 0.48 eV

D. stopping potential is 0.48 eV

Answer: A::B::C::D

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4. n number of photons of frequency f are emitted per second from a light source of power P (h = Planck's constant, c = speed of light). Then

A. $n = \frac{P}{hf}$

B. energy of each photon $= \frac{P}{cn}$

C. momentum of each photon $= \frac{P}{cn}$

D. value of n increases if the wavelength of the light increases

Answer: A::C::D

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5. The threshold frequency and the threshold wavelength of photoelectric emission from a metal surface are f_0 and λ_0. The frequency and the wavelength of incident light are f and λ. Then

A. there will be no photoelectric effect if $f > f_0$

B. there will be no photoelectric effect if $\lambda > \lambda_0$

C. stopping potential $\propto (f - f_0)$

D. maximum kinetic energy of photoelectron $\propto (\lambda_0 - \lambda)$

Answer: B::C

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6. Work functions of two metals A and B are 3.1 eV and 1.9 eV respectively. Light of wavelength 3000Å is incident on both the surfaces.

A. no photoemission will take place in case of metal A

B. photoelectrons will be emitted from both the metals

C. maximum kinetic energy of the photoelectron will be higher in metal B

D. threshold wavelength of photoelectric effect in case of metal A will be 4000Å approximately

Answer: B::C::D

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7. The de Broglie wavelength of a moving particle of mass m is λ. For a few particles of different masses

A. $\lambda \propto \frac{1}{m}$, if their momenta are same

B. $\lambda \propto \frac{1}{m}$, if their velocities are same

C. $\lambda \propto \frac{1}{m}$, if their kinetic energies are same

D. $\lambda \propto \frac{1}{\sqrt{m}}$, if their kinetic energies are same

Answer: B::D

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8. An electron (mass m) and a proton (mass M) are accelerated with same potential difference, then

A. ratio of the velocities $=\sqrt{\frac{M}{m}}$

B. ratio of the momenta $=\sqrt{\frac{M}{m}}$

C. ratio of their kinetic energies = 1

D. ratio of their de Broglie wavelength = $\sqrt{\frac{M}{m}}$

Answer: A::C::D

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9. The wavelength of K_α X-ray for lead isotopes $Pb^{208}, Pb^{206}, Pb^{204}$ and λ_1, λ_2 and λ_3 respectively. Then

A. $\lambda_1 = \lambda_2 = \lambda_3$

B. $\lambda_1 > \lambda_2 > \lambda_3$

C. $\lambda_1 < \lambda_2 < \lambda_3$

D. $\lambda_3 = \sqrt{\lambda_1 \lambda_2}$

Answer: A::D

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10. In which of the following situations the heavier of the two particles has smaller de Broglie wavelength? The two particles

A. move with the same speed

B. move with the same kinetic energy

C. move with the same linear momentum

D. have fallen through the same height

Answer: A::B::D

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Entrance Corner Comprehension Type

1. The energy (in eV) of each photon associated with the light of wavelength 5893Å

A. 2.1

B. 3.9

C. 4.2

D. 5.89

Answer: A

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2. Einstein established the idea of photons on the basis of Planck's quantum theory. According to his idea, the light of frequency f or wavelength λ is infact a stream of photons. The rest mass of each photon is zero and velocity is equal to the velocity of light $(c) = 3 \times 10^8 m.\ s^{-1}$. Energy, E = hf, where h = Planck's constant $= 6.625 \times 10^{-34} J.\ s$. Each photon has a momentum $p = \frac{hf}{c}$, although its rest mass is zero. The number of photons increase when the intensity of incident light increases and vice-versa.

On the other hand, according to de Broglie any stream of moving particles may be represented by progressive waves. The wavelength of the wave (de Broglie wavelength) is $\lambda = \frac{h}{p}$, where p is the momentum of the particle. When a particle having charge e is accelerated with a potential difference of V, the kinetic energy gained by the particle is K= eV. Thus as the applied potential difference is increased, the kinetic energy of the particle and hence the momentum increase resulting in a decrease in the de Broglie wavelength. Given, charge of electron, $e = 1.6 \times 10^{-19} C$ and mass $= 9.1 \times 10^{-31} kg.$

The number of photons emitted per second from a light source of power 40 W and wavelength $5893 Å$

A. 3.95×10^{11}

B. 1.186×10^{20}

C. 3.56×10^{20}

D. 3.56×10^{28}

Answer: B

Watch Video Solution

3. Einstein established the idea of photons on the basis of Planck's quantum theory. According to his idea, the light of frequency f or wavelength λ is infact a stream of photons. The rest mass of each photon is zero and velocity is equal to the velocity of light $(c) = 3 \times 10^8 m.\ s^{-1}$. Energy, E = hf, where h = Planck's constant $= 6.625 \times 10^{-34} J.\ s.$ Each photon has a momentum $p = \frac{hf}{c}$, although its rest mass is zero. The number of photons increase when the intensity of incident light increases and vice-versa.

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

The number of photons emitted per second by a source of light of power 30 W is 10^{20}, the momentum of each photon (in $kg. m. s^{-1}$)

A. 10^{-24}

B. 10^{-25}

C. 10^{-26}

D. 10^{-37}

Answer: D

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4. Einstein established the idea of photons on the basis of Planck's quantum theory. According to his idea, the light of frequency f or wavelength λ is infact a stream of photons. The rest mass of each photon is zero and velocity is equal to the velocity of light

$(c) = 3 \times 10^8 m.\ s^{-1}$. Energy, E = hf, where h = Planck's constant $= 6.625 \times 10^{-34} J.\ s$. Each photon has a momentum $p = \frac{hf}{c}$, although its rest mass is zero. The number of photons increase when the intensity of incident light increases and vice-versa.

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Two stationary electrons are accelerated with potential difference V_1 and V_2 respectively such that $V_1 : V_2 = n$. The ratio of their de Broglie wavelength

A. $\sqrt{n}$

B. $\frac{1}{\sqrt{n}}$

C. n^2

D. $\frac{1}{n^2}$

Answer: B

Watch Video Solution

5. Einstein established the idea of photons on the basis of Planck's quantum theory. According to his idea, the light of frequency f or wavelength λ is infact a stream of photons. The rest mass of each photon is zero and velocity is equal to the velocity of light $(c) = 3 \times 10^8 m. s^{-1}$. Energy, E = hf, where h = Planck's constant $= 6.625 \times 10^{-34} J. s$. Each photon has a momentum $p = \frac{hf}{c}$, although its rest mass is zero. The number of photons increase when the intensity of incident light increases and vice-versa.

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A proton is 1836 times heavier than an electron and has same charge as that of electron. For what velocity of the proton will its de Broglie wavelength be 4455Å

A. $10^6 m.\ s^{-1}$

B. $10^7 m.\ s^{-1}$

C. $3 \times 10^6 m.\ s^{-1}$

D. $3 \times 10^7 m. s^{-1}$

Answer: C

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6. Einstein's equation for photoelectric effect is $E_{\max} = hf - W_0$, where h = Planck's constant $= 6.625 \times 10^{-34} J. s$, $f =$ frequency of light incident on metal surface, W_0= work function of metal and $E_{\max}$= maximum kinetic energy of the emitted photoelectrons.

It is evident that if the frequency f is less than a minimum value f_0 or if the wavelength λ is greater than a maximum value λ_0, the value of $E_{\max}$ would be negative, which is impossible. Thus for a particular metal surface f_0 is the threshold frequency and λ_0 is the threshold wavelength for photoelectric emssion to take place. Again if the collector plate is ketp at a negative potential with respect to the emitter plate, the velocity of the photoelectrons would decrease. The minimum potential for which the velocity of the speediest electron becoes zero, is known as the stopping potential, the photoelectric effect stops for a potential lower than this.

[velocity of light $= 3 \times 10^8 m. s^{-1}$, mass of an electron $m = 9.1 \times 10^{-31} kg$, charge of an electron, $e = 1.6 \times 10^{-19} C$

The threshold wavelength of photoelectric effect for a metal surface is 4600Å. Work function of the metal (in eV) is

A. 2.7

B. 3.45

C. 4.2

D. 6.9

Answer: A

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7. Einstein's equation for photoelectric effect is $E_{\max} = hf - W_0$, where h = Planck's constant $= 6.625 \times 10^{-34} J.\ s$, $f =$ frequency of light incident on metal surface, W_0= work function of metal and $E_{\max}$= maximum kinetic energy of the emitted photoelectrons.

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[velocity of light $= 3 \times 10^8 m.\ s^{-1}$, mass of an electron $m = 9.1 \times 10^{-31} kg$, charge of an electron, $e = 1.6 \times 10^{-19} C$

Ultraviolet of wavelength 1800Å is incident on the metal surface. The maximum velocity of the emitted photoelectron (in $m.\ s^{-1}$) is

A. 8.5×10^5

B. 1.2×10^6

C. 1.7×10^5

D. 2.4×10^6

Answer: B

View Text Solution

8. Einstein's equation for photoelectric effect is $E_{\max} = hf - W_0$, where h = Planck's constant $= 6.625 \times 10^{-34} J.\ s,\ f =$ frequency of light incident on metal surface, W_0= work function of metal and $E_{\max}$= maximum kinetic energy of the emitted photoelectrons.

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[velocity of light $= 3 \times 10^8 m. s^{-1}$, mass of an electron $m = 9.1 \times 10^{-31} kg$, charge of an electron, $e = 1.6 \times 10^{-19} C$

The stopping potential in case of incident ultravilet ray of wavelength $1800 Å$ (in V) is

A. 2.7

B. 3.45

C. 4.2

D. 6.9

Answer: C

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Entrance Corner Integer Answer Type

1. The threshold frequency of photoelectric effect of a metal surface is f_0. The stopping potentials are V_0 and nV_0 when the frequencies of incident light are $2f_0$ and $4f_0$. What is the value of n ?

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2. If the power of the source of incident light is increased 4 times, by what factor would the maximum velocity of the photoelectron increase?

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3. The threshold frequency of photoelectric effect of a metal surface is f_0. The maximum velocities of the photoelectrons are v_m and $2v_m$ respectively when light waves of frequency $2f_0$ and nf_0 are incident on the surface. What is the value of n?

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4. The threshold frequency of photoelectric effect of a metal surface is f_0. The maximum kinetic energy of the photoelectron are $E_{\max}$ and $2E_{\max}$ respectively, when light waves of frequencies $2f_0$ and nf_0 are incident on the surface. What is the value of n?

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5. The ratio of the power of two sources of light is 2 and the ratio of wavelengths of the emerging monochromatic beam is also 2. What is the ratio of number of photons emitted per second.

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6. Both the mass and kinetic energy of two moving particles are in the ratio $\frac{1}{2}$. Find the ratio of their de Broglie wavelengths.

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7. The momentum of two moving particles are equal, but the kinetic energy of the first particles is 4 times that of the second. Find the ratio of their de Broglie wavelengths.

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8. The mass of an electron $= 9.1 \times 10^{-31} kg$ and Planck's constant $= 6.625 \times 10^{-34} J. s$. What is the de Broglie wavelength (in Å) of the electron if its velocity is $7.28 \times 10^6 m. s^{-1}$?

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9. The work function of silver and sodium are 4.6 eV and 2.3 eV respectively. What is the ratio of slope of stopping potential versus frequency plot for silver to that of sodium?

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Examination Archive With Solutions

1. What will be the kinetic energy of emitted photoelectrons if light of threshold frequency falls on a metal?

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2. State de Broglie's hypothesis and write down the expression for the wavelength of matter waves.

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3. Draw a graph to show the dependence of stopping potential on the frequency of incident light in case of photoelectric effect. Indicate the threshold frequency in the graph.

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4. The wavelength of matter waves associated with an electron of mass m having kinetic energy E is given by (h is Planck's constant)

A. $\frac{2h}{mE}$

B. 2mhE

C. $\frac{2\sqrt{2mE}}{h}$

D. $\frac{h}{\sqrt{2mE}}$

Answer: D

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5. What is meant by stopping potential in photoelectric emission ? Does the stopping potential depend on (i) the intensity and (ii) the frequency of the incident light ? Explain

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6. What conclusion is drawn from Davisson-Germer experiment? Are matter waves electromagnetic waves? Explain?

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7. For a monochromatic light incident on a metal surface, the maximum velocity of the emitted photoelectrons is v. Then the stopping potential would be

A. $\frac{2mv^2}{e}$

B. $\frac{mv^2}{e}$

C. $\frac{mv^2}{2e}$

D. $\frac{mv^2}{\sqrt{2}e}$

Answer: C

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8. Write down Einstein's photoelectric equation and mention the symbols used.

The photoelectric threshold wavelength for a certain metal is 400 nm. Find the maximum kinetic energy of the emitted electrons from the metal surface by ultraviolet light of wavelength 200 nm. Given, $h = 6.63 \times 10^{-34} J. s$

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9. 'Production of X-rays and emission of electron in photoelectric effect are two opposite phenomena" Justify the statement.

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10. Find the energy required by an electron to have its de Broglie wavelength reduced from $10^{-10} m$ to $0.5 \times 10^{-10} m$.

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11. When green light is incident on a certain metal surface, electrons are emitted but no electrons are emitted with yellow light. If red light is incident on the same metal surface.

A. more energetic electrons will be emiited

B. less energetic electrons will be emitted

C. emission of electrons will depend on the intensity of light

D. no electrons will be emitted

Answer:

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12. Draw the curve showing the variation of de Broglie wavelength of a particle with its momentum.

Find the momentum of a photon of wavelength 0.01Å

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13. Mention the inference of Davission Garmer experiment

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14. Define stopping potential

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15. When light of wavelength λ and 2λ are incident on a metal surface, the stopping potentials are V_0 and $V_0/4$ respectively. If c be the velocity of light in air, find the threshold frequency of photoelectric emission.

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16. The wavelength of de Broglie waves associated with a thermal neutron of mass m at absolute temperature T is given by (k is the Boltzmann constant)

A. $\frac{h}{\sqrt{mkT}}$

B. $\frac{h}{\sqrt{2mkT}}$

C. $\frac{h}{\sqrt{3mkT}}$

D. $\frac{h}{2\sqrt{mkT}}$

Answer: C

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17. Find the correct statements about photoelectric effect.

A. There is no significant time delay between the absorption of a suitable radiation and the emission of electrons

B. Einstein analysis given a threshold frequency above which no electron can be emitted

C. The maximum kinetic energy of the emitted photoelectrons is proportional to the frequency of incident radiation

D. The maximum kinetic energy of electrons does not depend on the intensity of radiation.

Answer: A::D

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18. The de Broglie wavelength of an electron is the same as that 50 keV X-ray photon. The ratio of the energy of the photon to the kinetic energy of the electron is (the energy equivalent of electron mass is 0.5 MeV)

A. $1 : 50$

B. $1:20$

C. $20:1$

D. $50:1$

Answer: C

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19. The work function of metals is in the range of 2 eV to 5 eV. Find which of the following wavelength of light cannot be used for photoelectric effect. (Consider, Planck's constant $= 4 \times 10^{-15} eV.s$, velocity of light $= 3 \times 10^8 m/s$)

A. 510 nm

B. 650 nm

C. 400 nm

D. 570 nm

Answer: B

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20. Consider two particles of different masses. In which of the following situations the heavier of the two particles will have smaller de Broglie wavelength?

A. both have a free fall through the same height

B. both move with the same kinetic energy

C. both move with the same linear momentum

D. both move with the same speed

Answer: A::B::D

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21. The potential difference V required for accelerating an electron to have de Broglie wavelength of 1Å is

A. 100 V

B. 125 V

C. 150 V

D. 200 V

Answer: C

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22. The work function of cesium is 2.27 eV. The cut-off voltage wich stops the emission of electrons from a cesium cathode irradiated with light of 600 nm wavelength is

A. 0.5 V

B. $0.2V$

C. $-0.5V$

D. 0.2 V

Answer: C

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23. The distance between a light source and photoelectric cell is d. If the distance is decreased to $\frac{d}{2}$ then

A. the emission of electron per second will be four times

B. maximum kinetic energy of photoelectrons will be four times

C. stopping potential will remain same

D. the emission of electron per second will be doubled

Answer: A::C

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24. The de Broglie wavelength of an electron is $0.4 \times 10^{-10} m$ when its kinetic energy is 1.0 keV. Its wavelength will be $1.0 \times 10^{-10} m$, when its kinetic energy is

A. 0.2 keV

B. 0.8 keV

C. 0.63 keV

D. 0.16 keV

Answer: D

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25. When light of frequency v_1 is incident on a metal with work function W (where $hv_1 > W$) the photocurrent falls to zero at a stopping potential of V_1. If the frequency of light is increased to v_2, the stopping potential changes to V_2. Therefore the charge of an electron is given by

A. $\dfrac{W(v_2+v_1)}{v_1V_2+v_2V_1}$

B. $\dfrac{W(v_2+v_1)}{v_1V_1+v_2V_2}$

C. $\dfrac{W(v_2-v_1)}{v_1V_2-v_2V_1}$

D. $\dfrac{W(v_2-v_1)}{v_2V_2-v_1V_1}$

Answer: C

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26. An electron accelerated through a potential of 10000 V from rest has a de Broglie wavelength λ. What should be the accelerating potential so that the wavelength is doubled?

A. 20000 V

B. 40000 V

C. 5000 V

D. 2500 V

Answer: D

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

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

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

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

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

Answer: A

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28. A particle A of mass m and initial velocity v collides with a particle of B of mass $\frac{m}{2}$ which is at rest. The collision is head-on and elastic. The ratio of the de Broglie wavelengths $\lambda_A \text{to} \lambda_B$ after collision is

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

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

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

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

Answer: B

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

A. 0.65 eV

B. 1.0 eV

C. 1.3 eV

D. 1.5 eV

Answer: B

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30. If the kinetic energy of the particle is increase to 16 times its previous value, the percentage change in the de Broglie wavelength of the paarticle is

A. 0.25

B. 0.75

C. 0.6

D. 0.5

Answer: B

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31. A radiation of energy E falls normally on a perfectly reflecting surface. The momentum transferred to the surface is (c = velocity of light)

A. $\frac{E}{c}$

B. $\frac{2E}{c}$

C. $\frac{2E}{c^2}$

D. $\frac{E}{c^2}$

Answer: B

Watch Video Solution

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

A. 6λ

B. 4λ

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

D. $\frac{\lambda}{6}$

Answer: B

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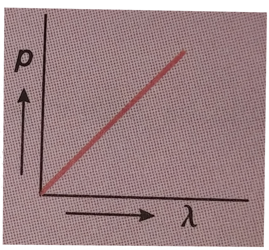
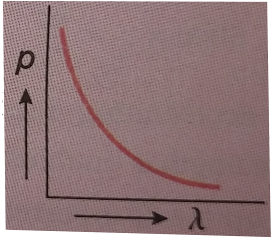
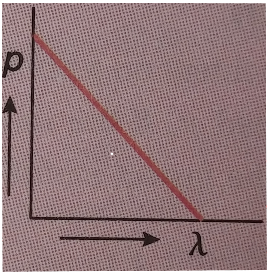
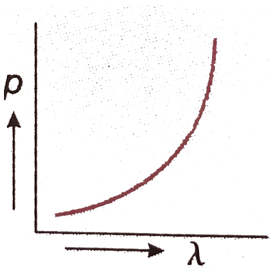
33. Which of the following figures represent the variation of particle momentum and the associated de Broglie wavelength?

A. 

B. 

C. 

D. 

Answer: B

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

A. 5λ

B. $\frac{5}{2}\lambda$

C. 3λ

D. 4λ

Answer: C

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35. An electron of mass m and a photon have same energy E. The ratio of de Broglie wavelength associated with them is

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

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

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

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

Answer: D

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

A. $1.4 \times 10^{-11} m$

B. $1.6 \times 10^{-10} m$

C. $1.65 \times 10^{-11} m$

D. $1.4 \times 10^{-10} m$

Answer: C

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37. In an experiment of photoelectric effect the stopping potential was measured to be V_1 and V_2 with incident light of wavelength λ and $\frac{\lambda}{2}$, respectively. The relation between V_1 and V_2 is

A. $V_2 > 2V_1$

B. $V_2 < V_1$

C. $V_1 < V_2 < 2V_1$

D. $V_2 = 2V_1$

Answer: A

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38. An electron of mass m with an initial velocity $\overrightarrow{V} = V_0\hat{i}(V_0 > 0)$ enters an electric field $\overrightarrow{E} = -E_0\hat{i}$ (E_0 = constant > 0) at t = 0. If

λ_0 is its de Broglie wavelength initially, then its de Broglie wavelength at time t is

A. $\lambda_0 t$

B. $\lambda_0 \left(1 + \frac{eE_0}{mV_0} t\right)$

C. $\frac{\lambda_0}{\left(1 + \frac{eE_0}{mV_0} t\right)}$

D. λ_0

Answer: C

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39. When the light of frequency $2v_0$ (where v_0 is threshold frequency) is incident on a metal plate, the maximum velocity of electrons emitted is v_{01}. When the frequency of the incident radiation is increased to $5v_0$, the maximum velocity of electrons emitted from the same plate is v_2. The ratio of $v_1 \rightarrow v_2$ is

A. $4:1$

B. $1:4$

C. $1:2$

D. $2:1$

Answer: C

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1. Define the terms (i) 'cut-off voltage' and (ii) 'threshold frequency' in relation to phenomenon of photoelecric effect.

Using Einstein's photoelectric equation show how the cutt-off voltage and threshold frequency for a given photosensitive material can be determined with the help of a suitable plot/graph.

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

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3. Write Einstein's photoelectric equation and point out any two characterstic properties of photons on which this equation is based.

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4. An electron microscope uses electrons, accelerated by a voltage of 50kV. Determine the de Broglie wavelength associated with the electrons. Taking other facters, such as numerical aperature etc. to same, how does the resolving power of an electron microscope compare with that of an optical microscope which uses yellow light.

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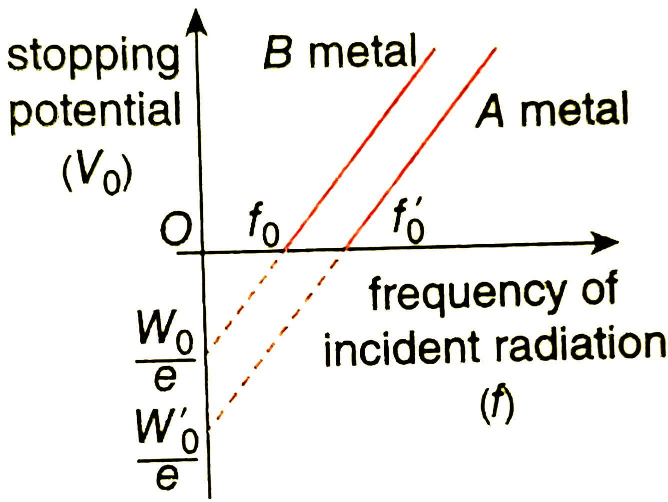
5. The graph shows the variation of stopping potential with frequency of incident radiation for two photosensitive metal A and B. Which one of the two has higher value of work function? Justify your answer.



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6. Determine the value of the de Broglie wavelength associated with the electron orbiting in the ground state of hydrogen atom (given $E_n = -(13.6/n^2)eV$ and bohr radius $r^0 = 0.53\text{Å}$). How will the de Broglie wavelength change when it is in the first excited state?

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7. Define the term 'intensity of radiation in photon picture of light. Ultraviolet light of wavelength 2270Å from 100W mercury source irradiates a photo cell made of a given metal. If the stopping potential is -1.3V, estimate the work function of the metal. How would the photon cell respond to a high intensity $(\sim 10^5 W.m^{-2})$ red light of wavelength 6300Å produced by a laser?

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8. A proton and an αparticle are accelerated through the same potential difference. Which one of the two has

greater de Broglie wavelength,

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9. A proton and an αparticle are accelerated through the same potential difference. Which one of the two has

less kinetic energy? Justify your answer.

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10. State two important properties of photon which are used to write Einstein's photoelectric equation. Define (a) stopping potential and (b) threshold frequency, using Einstein's equation and drawing necessary plot between relevant quantities.

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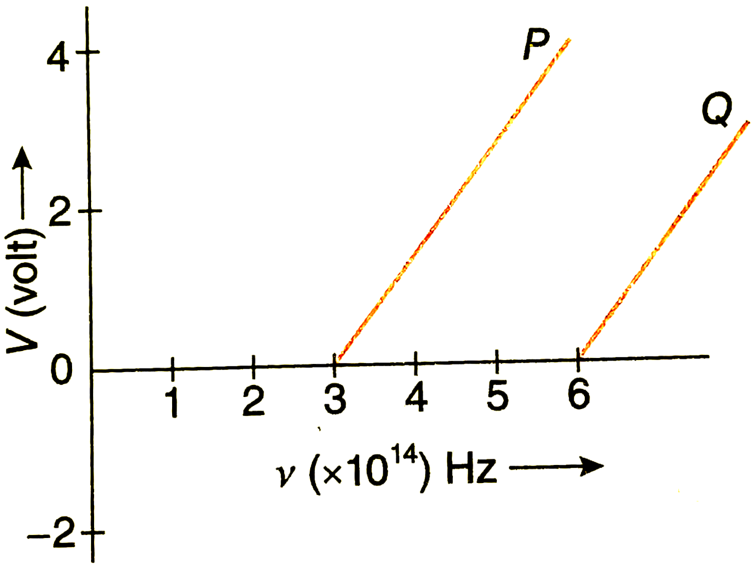
11. In the study of a photoelectric effect the graph between the stopping potential V and frequecy v of the incident radiation on two different metals P and Q shown in

Which one of the two metals has higher threshold frequency?



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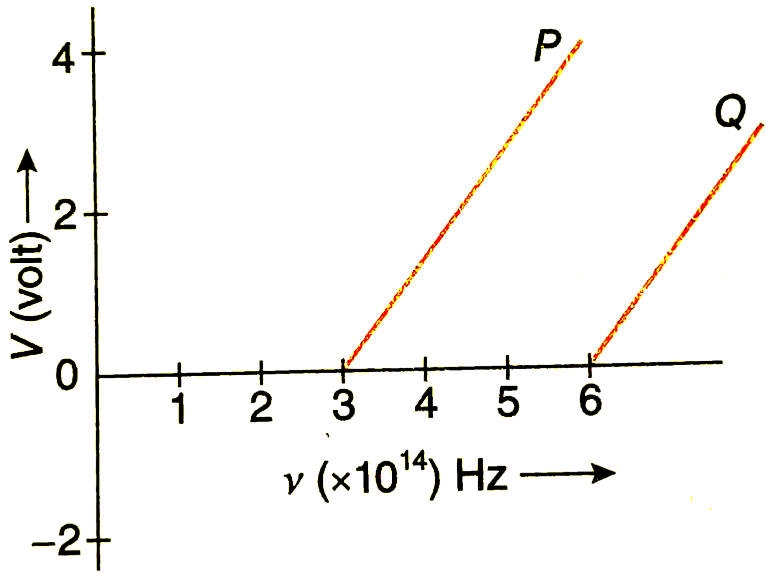
12. In the study of a photoelectric effect the graph between the stopping potential V and frequecy v of the incident radiation on two different metals P and Q shown in

(b) Determine the work function of the metal which has greater value.



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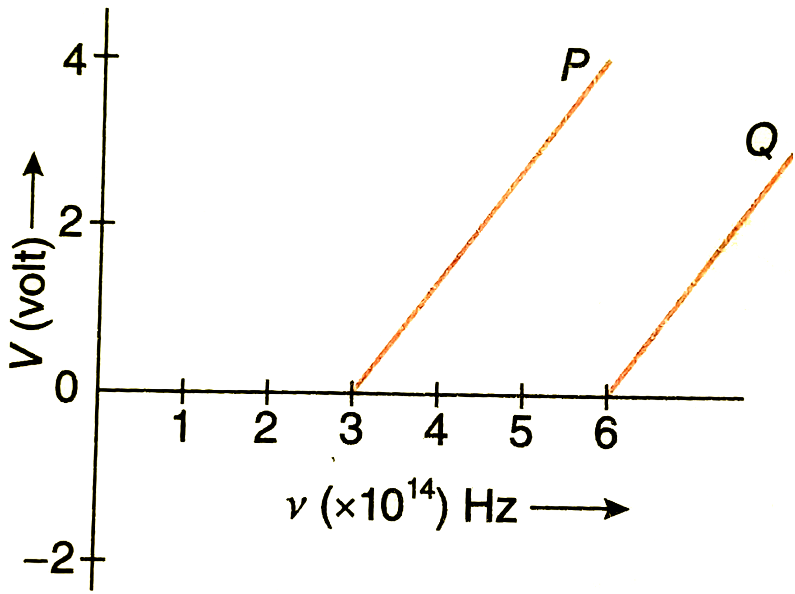
13. In the study of a photoelectric effect the graph between the stopping potential V and frequecy v of the incident radiation on two different metals P and Q shown in

Find the maximum kinetic energy of electron emitted by light of frequency $8 \times 106^{14} Hz$ for this metal.



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14. Using photon picture of light, show how Einstein's photoelectric equation can be established. Write two features of photoelectric effect which cannot be explained by wave theory.

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15. Name the phenomenon which shows the quantum nature of electromagnetic radiation.

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16. Give reason for maximum kinetic energy of the photoelectrons is independent of the intensity of incident radiation.

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17. Explain giving reasons for the following:

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

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18. Explain giving reasons for the following:

The stopping potential (V^0) varies linearly with the frequency (v) of the incident radiation for a given photosensitive surface with the slope remaining the same for different surfaces.

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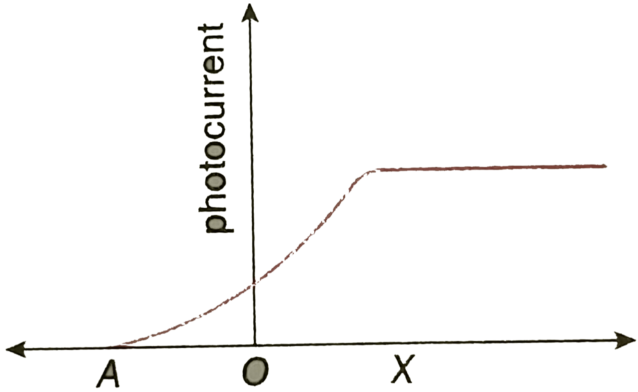
19. The following graph shows the variation of photocurrent for a photosensitive metal:

Identify the variable X on the horizontal axis.



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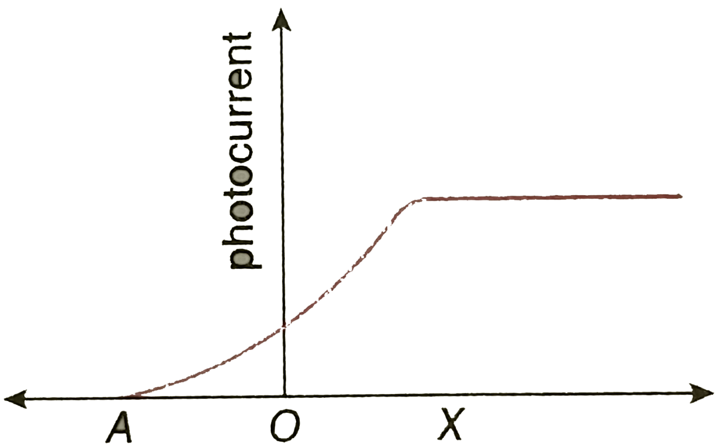
20. The following graph shows the variation of photocurrent for a photosensitive metal:

What does the point A on the horizontal axis represent?



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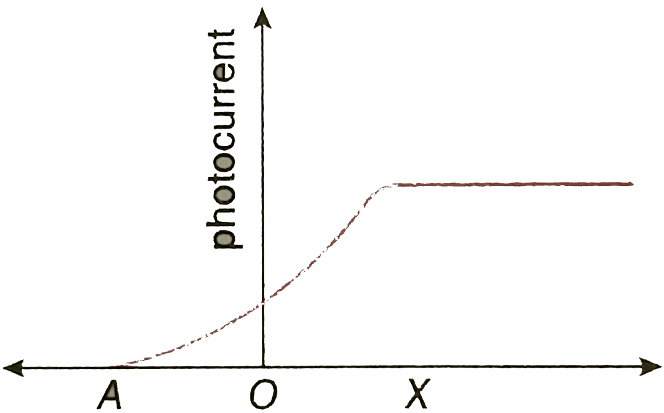
21. The following graph shows the variation of photocurrent for a photosensitive metal:

Draw this graph for three different values of frequencies of incident radiation v_1, v_2 and $v_3 (v_1 > v_2 > v_3)$ for same intensity.



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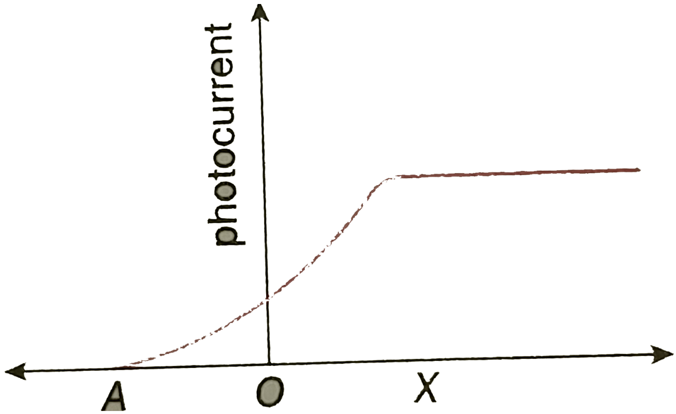
22. The following graph shows the variation of photocurrent for a photosensitive metal:

Draw this graph for three different values of intensities of incident radiation I_1, I_2 and $I_3 (I_1 > I_2 > I_3$ having same frequency.



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23. How does one explain the emission of electrons from a photosensitive surface with the help of Einstein's photoelectric equation?

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24. The work function of the following metals are given: $Na = 2.75eV, K = 2.3eV, Mo = 4.17eV$ and $Ni = 5.15eV$. Which of these metals will not cause photoelectric emission for radiation of wavelength $3300Å$ from laser source placed 1m away from these matals? What happens if the laser source is brought nearer and placed 50cm away?

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25. State two important features of Einstein's photoelectric equation.

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26. Radiation of frequency $10^{15} Hz$ is incident on two photosensitive surface P and Q. There is no photosensitive from surface P. Photoemission occurs from surface Q but photoelectrons have zero kinetic energy. Explain these observations and find the value of work function for surface Q.

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27. An α-particle and a proton are accelerated through the same potential difference. Find the ratio of de Broglie wavelengths.

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28. Draw graphs showing variation of photoelectric current with applied voltage for two incident radiations of equal frequency and different instensities. Mark the graph for the radiation of higher instensity.

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29. If light of wavelength 412.5nm is incident on each of the metals in the table, Which ones will show photoelectric emission and why?

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

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