CLASS 12 PHYSICS NCERT SOLUTIONS

# NCERT Solutions for Class 12 Physics Chapter 11: Dual Nature of Radiation and Matter – Free PDF Download

Chapter 11 covers the dual nature of radiation and matter — electron emission, the photoelectric effect and Einstein's photoelectric equation, photon energy and momentum, and the de Broglie wavelength of matter waves. As with the previous chapter, the "Additional Exercises" section from older editions has been rem...

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## NCERT Exercise Solutions

**11.1 In an X-ray tube, electrons are accelerated through a potential difference of 30kV before striking a target. (a) Find the maximum frequency of the X-rays produced. (b) Find the minimum wavelength of the X-rays produced.**
Ans: The maximum photon energy equals the full kinetic energy gained by an electron, eV. (a) $\nu_{max}$=eV/h=(1.6×10$^{-19}$×30000)/(6.626×10$^{-34}$)≈**7.24×10$^{18}$Hz**. (b) $\lambda_{min}$=hc/(eV)=**4.14×10$^{-11}$m (0.0414nm)**.

**11.2 The work function of caesium is 2.14eV. Light of frequency 6×10$^{14}$Hz is incident on a caesium surface. Find (a) the maximum kinetic energy of the emitted photoelectrons, (b) the stopping potential, (c) the maximum speed of the emitted photoelectrons.**
Ans: Photon energy=hν=4.136×10$^{-15}$×6×10$^{14}$≈2.48eV. (a) $KE_{max}$=2.48−2.14=**0.34eV**. (b) Stopping potential $V_0$=$KE_{max}$/e=**0.34V**. (c) Using $KE_{max}$=½mv$^2$: v=**3.46×10$^5$m/s**.

**11.3 The photoelectric cut-off voltage for a certain metal is 1.5V. What is the maximum kinetic energy of the emitted photoelectrons?**
Ans: $KE_{max}$=e$V_0$=1.5eV=**2.4×10$^{-19}$J**.

**11.4 A 632.8nm helium-neon laser has a power output of 9.42mW. (a) Find the energy and momentum of each photon. (b) How many photons per second, on average, are emitted by the source? (c) Find the speed of a hydrogen atom for which the de Broglie wavelength equals the wavelength of this light.**
Ans: (a) E=hc/λ=**3.14×10$^{-19}$J (1.96eV)**, p=h/λ=**1.05×10$^{-27}$kg m/s**. (b) Photons/s=P/E=9.42×10$^{-3}$/3.14×10$^{-19}$≈**3×10$^{16}$**. (c) v=p/$m_H$=1.05×10$^{-27}$/1.66×10$^{-27}$≈**0.63m/s**.

**11.5 The energy flux of sunlight reaching a surface is used in an experiment on the photoelectric effect. A plot of the cut-off voltage against frequency of incident light gives a straight line whose slope is found to be 4.12×10$^{-15}$Vs. Calculate the value of Planck's constant.**
Ans: Since e$V_0$=hν−h$\nu_0$, the slope of $V_0$ vs ν equals h/e. h=slope×e=4.12×10$^{-15}$×1.6×10$^{-19}$≈**6.59×10$^{-34}$Js** — about 0.5% below the accepted value (6.626×10$^{-34}$Js), the small gap coming from experimental measurement error.

**11.6 The threshold frequency for a metal is 3.3×10$^{14}$Hz. If light of frequency 8.2×10$^{14}$Hz is incident on this metal, determine the cut-off voltage for the photoelectric emission.**
Ans: e$V_0$=h(ν−$\nu_0$)=6.626×10$^{-34}$×(8.2−3.3)×10$^{14}$. $V_0$=**2.03V**.

**11.7 The work function of a metal is 4.2eV. If radiation of wavelength 330nm is incident on the metal, does photoelectric emission take place?**
Ans: Photon energy=1240/330≈3.76eV, which is **less than** the work function of 4.2eV. **No photoelectric emission occurs** — the incident photons don't carry enough energy to overcome the work function, regardless of intensity.

**11.8 Light of frequency 7.21×10$^{14}$Hz is incident on a metal surface. Electrons with a maximum speed of 6.0×10$^5$m/s are ejected from the surface. Find the threshold frequency for photoemission of electrons from this surface.**

Ans: $KE_{max}=\frac{1}{2}mv^2=\frac{1}{2}\times9.11\times10^{-31}\times(6.0\times10^5)^2\approx1.64\times10^{-19}$J.
$v_0=v-KE_{max}/h=7.21\times10^{14}-2.48\times10^{14}\approx$**$4.74\times10^{14}$Hz.**

**11.9 Light of wavelength 488nm is produced by an argon laser. When this light is incident on a metal surface, the stopping potential is found to be 0.38V. Find the work function of the metal.**
Ans: Photon energy=1240/488≈2.54eV. Work function=$E_{photon}-eV_0$=2.54−0.38=**2.16eV**.

**11.10 Find the de Broglie wavelength associated with (a) a bullet of mass 0.040kg travelling at 1.0km/s, (b) a ball of mass 0.060kg moving at 1.0m/s, (c) a dust particle of mass $1.0\times10^{-9}$kg drifting at 2.2m/s.**
Ans: Using $\lambda=h/(mv)$. (a) $\lambda=6.626\times10^{-34}/(0.040\times1000)=$**$1.66\times10^{-35}$m**. (b) $\lambda=6.626\times10^{-34}/(0.060\times1.0)=$**$1.10\times10^{-32}$m**. (c) $\lambda=6.626\times10^{-34}/(1.0\times10^{-9}\times2.2)=$**$3.01\times10^{-25}$m**. All three are far too small to observe any wave behaviour, showing why everyday objects never show noticeable matter-wave effects.

**11.11 An electron and a photon each have a wavelength of 1.00nm. Show, in general, that the de Broglie wavelength of a photon of electromagnetic radiation equals the wavelength of the radiation itself.**
Ans: For a photon, momentum p=E/c (from relativity), and energy $E=h\nu=hc/\lambda_{radiation}$. So $p=h/\lambda_{radiation}$. The de Broglie relation gives $\lambda_{de\ Broglie}=h/p=h/(h/\lambda_{radiation})=\boldsymbol{\lambda_{radiation}}$ — the photon's de Broglie wavelength is identically equal to the wavelength of the electromagnetic wave it belongs to, for any photon of any energy.

## Class 12 Physics Chapter 11 – Notes and Extra Questions

Along with these NCERT Solutions, students can also use the Class 12 Physics Chapter 11 Extra Questions and Class 12 Physics Chapter 11 Revision Notes for quick revision and extra practice.

**See also:** Chapter 1 | Chapter 2 | Chapter 3 | Chapter 4 | Chapter 5 | Chapter 6 | Chapter 7 | Chapter 8 | Chapter 9 | Chapter 10

**Practice more:** Chapter 1 | Chapter 2 | Chapter 3 | Chapter 4 | Chapter 5 | Chapter 6 | Chapter 7 | Chapter 8 | Chapter 9 | Chapter 10

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