CLASS 12 PHYSICS — FORMULA SHEET

Chapter 11 : Dual Nature of Radiation and Matter (NCERT)

11.1 Electron Emission & Work Function

Concept	Detail
Work function (φ_0)	Minimum energy to free an electron from a metal surface
Threshold frequency (ν_0)	Minimum frequency for emission ; $\varphi_0 = h\nu_0$
Threshold wavelength (λ_0)	$\lambda_0 = hc \div \varphi_0 = c \div \nu_0$
Types of emission	Thermionic, photoelectric, field, secondary
1 electron volt (eV)	$= 1.6 \times 10^{-19}$ J

11.2 Photoelectric Effect

Concept	Formula / Law
Einstein's photoelectric equation	$h\nu = \varphi_0 + KE_{max} = h\nu_0 + \frac{1}{2}mv_{max}^2$
Max kinetic energy	$KE_{max} = h\nu - \varphi_0 = h(\nu - \nu_0)$
Stopping potential	$eV_0 = KE_{max} = h\nu - \varphi_0$
In terms of wavelength	$KE_{max} = hc(1/\lambda - 1/\lambda_0)$
Photon energy	$E = h\nu = hc/\lambda$
Effect of intensity	Intensity ↑ → number of photoelectrons ↑ (NOT their energy)
Effect of frequency	Frequency ↑ → KE_{max} ↑ (linear), if $\nu > \nu_0$
No emission if	$\nu < \nu_0$ (regardless of intensity)

11.3 Laws of Photoelectric Effect

Law	Statement
First law	Photoelectric current ∝ intensity of incident light
Second law	KE_{max} depends only on frequency, not on intensity
Third law	Below threshold frequency, no emission occurs
Fourth law	Emission is instantaneous (no time lag)
Stopping potential vs ν	Graph is a straight line ; slope = h/e

11.4 Photon — Particle Nature of Light

Property	Formula
Photon energy	$E = h\nu = hc/\lambda$
Photon momentum	$p = E/c = h/\lambda = h\nu/c$
Photon mass (rest)	Zero (rest mass) ; effective mass = E/c^2
Number of photons (power P)	$N = P \div (h\nu)$ per second

Property	Formula
Photon nature	Travels at speed c ; no charge ; not deflected by E or B fields

11.5 de Broglie Hypothesis (Matter Waves)

Concept	Formula
de Broglie wavelength	$\lambda = h \div p = h \div (mv)$
In terms of KE	$\lambda = h \div \sqrt{(2m \cdot KE)}$
For accelerated charge (V volts)	$\lambda = h \div \sqrt{(2mqV)}$
For electron	$\lambda = 12.27 \div \sqrt{V}$ Å (V in volts)
For gas at temperature T	$\lambda = h \div \sqrt{(3mkT)}$
Significance	Matter has wave nature ; significant only for microscopic particles

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Einstein equation	$h\nu = \varphi_0 + KE\_max$. Energy in = work function + leftover KE.
Stopping potential	$eV_0 = KE\_max$. Graph V_0 vs ν is a straight line with slope h/e.
Intensity vs frequency	Intensity → MORE electrons. Frequency → MORE energy per electron.
Threshold	No emission below ν_0, no matter how bright the light.
Photon momentum	$p = h/\lambda = E/c$. Photons carry momentum despite zero rest mass.
de Broglie	$\lambda = h/p = h/\sqrt{(2m \cdot KE)}$. For electron: $\lambda = 12.27/\sqrt{V}$ Å.
Heavier → smaller λ	Big or fast particles have tiny λ (why we don't see matter waves).
12400 / 12.27	Photon: $E(eV) \cdot \lambda(Å) = 12400$. Electron de Broglie: $\lambda = 12.27/\sqrt{V}$ Å.