CLASS 12 PHYSICS — FORMULA SHEET

Chapter 14 : Semiconductor Electronics (NCERT)

14.1 Classification of Solids (Energy Bands)

Type	Band Gap & Property
Conductor (metal)	No gap (overlapping bands) ; conducts freely
Insulator	Large band gap (> 3 eV) ; e.g. diamond ($_{6\ eV}$)
Semiconductor	Small band gap ($_{1\ eV}$) ; Si ≈ 1.1 eV, Ge ≈ 0.7 eV
Conduction band	Higher energy band where electrons conduct
Valence band	Lower band normally filled with electrons
Forbidden gap (E_g)	Energy gap between valence & conduction bands

14.2 Intrinsic & Extrinsic Semiconductors

Type	Detail
Intrinsic	Pure semiconductor ; $n_e = n_h = n_i$
Mass-action law	$n_e \times n_h = n_i^2$
Extrinsic	Doped semiconductor (more carriers)
n-type	Doped with pentavalent (P, As, Sb) ; electrons are majority
p-type	Doped with trivalent (B, Al, In) ; holes are majority
n-type carriers	$n_e >> n_h$; donor impurity
p-type carriers	$n_h >> n_e$; acceptor impurity
Conductivity	$\sigma = e(n_e\mu_e + n_h\mu_h)$

14.3 p-n Junction Diode

Concept	Detail
Depletion region	Charge-free zone at junction (immobile ions)
Potential barrier	Built-in voltage ($_{0.3\ V\ Ge,}$ 0.7 V Si)
Forward bias	p to +, n to − ; barrier ↓, current flows (low resistance)
Reverse bias	p to −, n to + ; barrier ↑, tiny leakage current (high resistance)
Diode equation	$I = I_0\ [e^{(eV/kT)} - 1]$
Knee/threshold voltage	Voltage where forward current rises sharply
Breakdown (reverse)	Avalanche or Zener breakdown at high reverse voltage

14.4 Diode Applications — Rectifiers

Concept	Detail / Formula
Rectifier	Converts AC to DC using diodes

Concept	Detail / Formula
Half-wave rectifier	Uses 1 diode ; conducts in one half-cycle only
Full-wave rectifier	Uses 2 diodes (centre-tap) ; both half-cycles
Ripple frequency (half-wave)	Same as input (f)
Ripple frequency (full-wave)	Twice the input (2f)
Efficiency (half-wave)	40.6%
Efficiency (full-wave)	81.2%
Filter	Capacitor smooths the pulsating DC output

14.5 Special Diodes

Diode	Use / Property
Zener diode	Operated in reverse breakdown ; voltage regulator
LED (light-emitting diode)	Forward biased ; emits light ($E_g \approx$ hv of emitted light)
Photodiode	Reverse biased ; current depends on light intensity
Solar cell	Generates EMF from light (no external bias)
LED wavelength	$\lambda = hc \div E_g$

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Band gaps	Conductor: 0 ; Semiconductor: 1 eV ; Insulator: >3 eV.
Si vs Ge	Si band gap 1.1 eV, barrier 0.7 V ; Ge 0.7 eV, barrier 0.3 V.
n-type vs p-type	n: pentavalent donor, electrons majority ; p: trivalent acceptor, holes majority.
Mass-action law	$n_e \times n\_h = n_i^2$ (always holds for a given temperature).
Forward vs reverse	Forward: low resistance, current flows. Reverse: high resistance, tiny leakage.
Rectifier ripple	Half-wave: ripple f. Full-wave: ripple 2f (smoother).
Efficiency	Half-wave 40.6% ; full-wave 81.2% (about double).
Special diodes	Zener → regulator ; LED → emits light ; Photodiode/Solar → detect/generate from light.