

Important Energy Band & Charge Carrier Formulas PDF



Formulas Examples with Units

List of 20 Important Energy Band & Charge Carrier Formulas

1) Carrier Lifetime Formula ↻

Formula

$$T_a = \frac{1}{\alpha_r \cdot (p_0 + n_0)}$$

Example with Units

$$3.6\text{E-}6\text{s} = \frac{1}{1.2\text{E-}6\text{m}^3/\text{s} \cdot (2.3\text{E}11\text{1}/\text{m}^3 + 1.4\text{E}7\text{1}/\text{m}^3)}$$

Evaluate Formula ↻

2) Concentration in Conduction Band Formula ↻

Formula

$$n_0 = N_c \cdot f_E$$

Example with Units

$$1.4\text{E+}7\text{1}/\text{m}^3 = 6.4\text{E}8\text{1}/\text{m}^3 \cdot 0.022$$

Evaluate Formula ↻

3) Concentration of Holes in Valence Band Formula ↻

Formula

$$p_0 = N_v \cdot (1 - f_E)$$

Example with Units

$$2.3\text{E+}11\text{1}/\text{m}^3 = 2.4\text{E}11\text{1}/\text{m}^3 \cdot (1 - 0.022)$$

Evaluate Formula ↻

4) Conduction Band Energy Formula ↻

Formula

$$E_c = E_g + E_v$$

Example with Units

$$17.5\text{eV} = 0.198\text{eV} + 17.302\text{eV}$$

Evaluate Formula ↻

5) Distribution Coefficient Formula ↻

Formula

$$k_d = \frac{C_{\text{solid}}}{C_L}$$

Example with Units

$$0.404 = \frac{1.01\text{E}15\text{cm}^{-1}}{2.5\text{E}15\text{cm}^{-1}}$$

Evaluate Formula ↻

6) Effective Density of State Formula ↻

Formula

$$N_c = \frac{n_0}{f_E}$$

Example with Units

$$6.4\text{E+}8\text{1}/\text{m}^3 = \frac{1.4\text{E}7\text{1}/\text{m}^3}{0.022}$$

Evaluate Formula ↻



7) Effective Density State in Valence Band Formula

Formula

$$N_V = \frac{p_0}{1 - f_E}$$

Example with Units

$$2.4\text{E}+11\text{ 1/m}^3 = \frac{2.3\text{e}11\text{ 1/m}^3}{1 - 0.022}$$

Evaluate Formula 

8) Energy Gap Formula

Formula

$$E_g = E_c - E_v$$

Example with Units

$$0.198\text{eV} = 17.5\text{eV} - 17.302\text{eV}$$

Evaluate Formula 

9) Energy of Electron given Coulomb's Constant Formula

Formula

$$E_e = \frac{n^2 \cdot \pi^2 \cdot [\text{hP}]^2}{2 \cdot [\text{Mass-e}] \cdot L^2}$$

Example with Units

$$121.1842\text{eV} = \frac{2^2 \cdot 3.1416^2 \cdot 6.6\text{E}-34^2}{2 \cdot 9.1\text{E}-31\text{kg} \cdot 7\text{e}-10^2}$$

Evaluate Formula 

10) Excess Carrier Concentration Formula

Formula

$$\delta_n = g_{op} \cdot \tau_n$$

Example with Units

$$1\text{E}+14\text{ 1/m}^3 = 2.9\text{e}19 \cdot 3.62\text{e}-6\text{s}$$

Evaluate Formula 

11) Fermi Function Formula

Formula

$$f_E = \frac{n_0}{N_c}$$

Example with Units

$$0.0219 = \frac{1.4\text{e}7\text{ 1/m}^3}{6.4\text{e}8\text{ 1/m}^3}$$

Evaluate Formula 

12) Intrinsic Carrier Concentration Formula

Formula

$$n_i = \sqrt{N_V \cdot N_c} \cdot \exp\left(-\frac{E_g}{2 \cdot [\text{BoltZ}] \cdot T}\right)$$

Example with Units

$$2.7\text{E}+8\text{ 1/m}^3 = \sqrt{2.4\text{e}11\text{ 1/m}^3 \cdot 6.4\text{e}8\text{ 1/m}^3} \cdot \exp\left(-\frac{0.198\text{eV}}{2 \cdot 1.4\text{E}-23\text{J/K} \cdot 300\text{K}}\right)$$

Evaluate Formula 

13) Liquid Concentration Formula

Formula

$$C_L = \frac{C_{\text{solid}}}{k_d}$$

Example with Units

$$2.5\text{E}+15\text{ cm}^{-1} = \frac{1.01\text{e}15\text{ cm}^{-1}}{0.41}$$

Evaluate Formula 



14) Net Rate of Change in Conduction Band Formula

Formula

$$\alpha_r = \frac{TG}{n_i^2}$$

Example with Units

$$1.2E-6 \text{ m}^3/\text{s} = \frac{8.7e10}{2.7e8 \text{ 1/m}^3^2}$$

Evaluate Formula 

15) Optical Generation Rate Formula

Formula

$$g_{op} = \frac{\delta_n}{\tau_n}$$

Example with Units

$$2.9E+19 = \frac{1.049e14 \text{ 1/m}^3}{3.62e-6 \text{ s}}$$

Evaluate Formula 

16) Photoelectron Energy Formula

Formula

$$E_{photo} = [hP] \cdot f$$

Example with Units

$$757.4472 \text{ eV} = 6.6E-34 \cdot 183.15 \text{ PHz}$$

Evaluate Formula 

17) Recombination Lifetime Formula

Formula

$$\tau_n = (\alpha_r \cdot p_0)^{-1}$$

Example with Units

$$3.6E-6 \text{ s} = (1.2e-6 \text{ m}^3/\text{s} \cdot 2.3e11 \text{ 1/m}^3)^{-1}$$

Evaluate Formula 

18) Steady State Electron Concentration Formula

Formula

$$n_{ss} = n_0 + \delta_n$$

Example with Units

$$1E+14 \text{ 1/m}^3 = 1.4e7 \text{ 1/m}^3 + 1.049e14 \text{ 1/m}^3$$

Evaluate Formula 

19) Thermal Generation Rate Formula

Formula

$$TG = \alpha_r \cdot (n_i^2)$$

Example with Units

$$8.7E+10 = 1.2e-6 \text{ m}^3/\text{s} \cdot (2.7e8 \text{ 1/m}^3^2)$$

Evaluate Formula 

20) Valence Band Energy Formula

Formula

$$E_v = E_c - E_g$$

Example with Units

$$17.302 \text{ eV} = 17.5 \text{ eV} - 0.198 \text{ eV}$$

Evaluate Formula 



Variables used in list of Energy Band & Charge Carrier Formulas above

- **C_L** Impurity Concentration in Liquid (1 per Centimeter)
- **C_{solid}** Impurity Concentration in Solid (1 per Centimeter)
- **E_c** Conduction Band Energy (Electron-Volt)
- **E_e** Energy of Electron (Electron-Volt)
- **E_g** Energy Gap (Electron-Volt)
- **E_{photo}** Photoelectron Energy (Electron-Volt)
- **E_v** Valence Band Energy (Electron-Volt)
- **f** Frequency of Incident Light (Petahertz)
- **f_E** Fermi Function
- **g_{op}** Optical Generation Rate
- **k_d** Distribution Coefficient
- **L** Potential Well Length
- **n** Quantum Number
- **n_0** Electron Concentration in Conduction Band (1 per Cubic Meter)
- **N_c** Effective Density of State in Conduction Band (1 per Cubic Meter)
- **n_i** Intrinsic Carrier Concentration (1 per Cubic Meter)
- **n_{ss}** Steady State Carrier Concentration (1 per Cubic Meter)
- **N_v** Effective Density of State in Valence Band (1 per Cubic Meter)
- **p_0** Holes Concentration in Valance Band (1 per Cubic Meter)
- **T** Temperature (Kelvin)
- **T_a** Carrier Lifetime (Second)
- **TG** Thermal Generation
- **α_r** Proportionality for Recombination (Cubic Meter per Second)
- **δ_n** Excess Carrier Concentration (1 per Cubic Meter)

Constants, Functions, Measurements used in list of Energy Band & Charge Carrier Formulas above

- **constant(s):** **π** , 3.14159265358979323846264338327950288
Archimedes' constant
- **constant(s):** **[BoltZ]**, 1.38064852E-23
Boltzmann constant
- **constant(s):** **[Mass-e]**, 9.10938356E-31
Mass of electron
- **constant(s):** **[hP]**, 6.626070040E-34
Planck constant
- **Functions:** **exp**, exp(Number)
n an exponential function, the value of the function changes by a constant factor for every unit change in the independent variable.
- **Functions:** **sqrt**, sqrt(Number)
A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.
- **Measurement:** **Time** in Second (s)
Time Unit Conversion 
- **Measurement:** **Temperature** in Kelvin (K)
Temperature Unit Conversion 
- **Measurement:** **Energy** in Electron-Volt (eV)
Energy Unit Conversion 
- **Measurement:** **Frequency** in Petahertz (PHz)
Frequency Unit Conversion 
- **Measurement:** **Volumetric Flow Rate** in Cubic Meter per Second (m³/s)
Volumetric Flow Rate Unit Conversion 
- **Measurement:** **Carrier Concentration** in 1 per Cubic Meter (1/m³)
Carrier Concentration Unit Conversion 
- **Measurement:** **Reciprocal Length** in 1 per Centimeter (cm⁻¹)
Reciprocal Length Unit Conversion 



- τ_n Recombination Lifetime (Second)



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