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Tut-1

Ans1:- 1kg coal → 30×10^6 J
→ 2.3 kg CO_2

Coal = ? for 100 W (24 hrs)

$\eta = 30\%$ → + CO_2 emission

① If $\eta = 30\%$
Total energy = $30 \times 10^6 \times \frac{30}{100}$
⇒ 9×10^6 J

② for 24 hr = $100 \times 24 \times 3600$
⇒ 8.64×10^6
(energy)

1 → kg → 9×10^6 → 1kg
for 8.64×10^6 →

Coal require ⇒ $\frac{8.64 \times 10^6}{9 \times 10^6}$

⇒ 960 gm.

1000 kg coal emit ⇒ 2.3 kg CO_2
for 900

⇒ $\frac{960}{1000} \times 2.3 \times 10^3$

⇒ 2.208 kg

Scanned by CamScanner

Ans 2 :→ Area = 640 km^2
$P = 2 \times 10^9$

Material = 7×10^9 kg

1kg → 1×10^6 J
(Energy)

(a) Total energy → $7 \times 10^6 \times 10^6$
→ 7×10^{15} kg

(b) $\frac{7 \times 10^{15}}{2 \times 10^9}$ → 3.5×10^6 seconds

(c) $1m^2$ → 250 w.
640 → $250 \times 640 \times \frac{12}{100}$

→ 1.92×10^{10} W

$1m^2$ → 2×10^9 W
640 → $2 \times 10^9 \times 640$

→ 1.28×10^{18}

Pay back time → $\frac{1.28 \times 10^{18}}{1.92 \times 10^{10}}$

(d) Solar → 6.6×10^7 J.

Ans3 :→ PV → 2.2 KW
Isolation → $\frac{4 \text{ kWh}}{m^2 \text{ day}}$

E = ? (year)

$E = \frac{\text{Size} \times \text{Isolation}}{\text{AM1.4m} \approx (1000 \text{ W/m}^2)}$

$\Rightarrow \frac{2.2 \times 10^3 \times 4 \times 10^3 \text{ W} \times m^2 \times 365}{1000 \text{ W} \times m^2 \times \text{day}}$

$\Rightarrow$ 3212 kW/year

Ans4 :→ Isolation = $\frac{6 \text{ kWh}}{m^2 \text{ day}}$

PV = 4×10^{12}
η = 0.12

land = $\frac{\text{Energy output}}{\text{Isolation} \times \text{eff}}$

$\Rightarrow \frac{4 \times 10^{12} \times 365}{6 \times 10^3 \times 0.12}$

$\Rightarrow 2.02 \times 10^{12} \ m^2$

Ans5:- $\eta \Rightarrow 45\%$

1 kg $\rightarrow 3 \times 10^6$ J

$\rightarrow$ 2.5 kg of CO_2

Total energy of Home

$\Rightarrow (15 \times 5 \times 6) + (100 \times 3 \times 8) + (200 \times 8) + (150 \times 12) + (200 \times 4)$

$\Rightarrow$ 7650 wh.

(a) for a day: $\Rightarrow 7650 \times 24 \times 360$

$\Rightarrow 6.6 \times 10^8$

$\eta \Rightarrow 45\%$ of 3×10^6

$\Rightarrow 3 \times 10^6 \times \frac{45}{100} \Rightarrow 135 \times 10^4$

Coal $\Rightarrow \frac{\cancel{135 \times 10^4}}{\cancel{6.6 \times 10^8}}$ $\frac{6.6 \times 10^8}{135 \times 10^4}$

$\Rightarrow$ 488.8 kg.

1000 gm $\rightarrow$ 2.5 kg CO_2

for 488.8 kg $\Rightarrow \frac{2.5}{1000} \times \frac{488.8}{1000} \times 10^3$

$\Rightarrow$ 1222 kg CO_2

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Ans 6 :→ $T_{sun} = 5800\,°C$
$T_{earth} = 18\,°C$

$E = \sigma A T^4$

$\Rightarrow 5.67 \times 10^{-8} \times 4\pi R_s^2 \times (5800)^4$

$\Rightarrow 5.67 \times 10^{-8} \times 4 \times \pi \times 7 \times 10^8 \times (5800)^4$

$\Rightarrow 3.95 \times 10^{26}\,J.$

$$\text{Mat atmosp} \Rightarrow \frac{E}{4\pi (R_e)^2}$$

$$\Rightarrow \frac{3.95 \times 10^{26}}{1.5 \times 10^{11}} \approx 1400\,W/m^2$$

for $\alpha = 30\%$

$I = (1-\alpha) I_0$

$\Rightarrow (1-0.30) \times 1400 \approx 960\,W/m^2$

Ans 7 :- $d = 900\,nm$
Si → 1.12
Ge → 0.7
GaAs = 1.47
GaPc = 1.56

$E_{ph} \geq E_g$

$E = \frac{hc}{d} \Rightarrow \frac{1240}{900} \Rightarrow (1.377\,eV)$

(Si & Ge)

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Ans 8:- $E_{ph} \geq E_g$ (given)

$E_g = 1.12 eV$

$\lambda = \frac{1240}{1.12} \Rightarrow 1100 nm$ (Infrared)

$\boxed{E = \frac{hc}{\lambda}}$

Ans 9:- $E = 2.5 eV$

$\lambda = ?$

$\nu = ?$

$\boxed{E = \frac{hc}{\lambda}} \rightarrow 2.5 = \frac{1240}{\lambda}$

$\lambda = \frac{1240}{2.5}$

$\boxed{\lambda = 496 nm}$

$freq = \frac{c}{\lambda}$

$\boxed{\nu = 2 \times 10^{-3} nm}$

Ans 10:- $E = ?$

$T = 300 K$

$\boxed{E = \frac{KT}{q}}$

$E = \frac{300 \times 1.36 \times 10^{-23}}{1.6 \times 10^{-19}}$

$\boxed{E = 25.8 meV}$

2019

Tut-2

Q1 → majority = ?

$n_i = 1.5 \times 10^{10}$

St → Semi

pendent

Ans 2:-

ries

tain

n of 9

he (iii)

maximum

has energy

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①

Tut-2

Ans1 → majority = ? minority = ?

$n_i = 1.5 \times 10^{10}$

Si → Semi
pentavel → 10^{16} → N type

(majority) $n_0 = 10^6 / cm^2$

$\boxed{n_0 \times p_0 = n_i^2}$

$10^{16} \times p_0 = (1.5 \times 10^{10})^2$
$p_0 \Rightarrow 2.25 \times 10^{04} / cm^2$

Ans2:

$\mu_n = 1400$
$\mu_p = 500$
$\boxed{\sigma = q_e(\mu_n) n_0 + q_p(\mu_p) n_p}$

$\Rightarrow 1.6 \times 10^{-19} \times 1400 \times 10^6 +$
$1.6 \times 10^{-19} \times \underbrace{500 \times 2.25 \times 10^{04}}_{\text{ignore}}$

$\boxed{\sigma \Rightarrow 2.24}$

$\boxed{\rho = \frac{1}{\sigma}}$

$\Rightarrow \frac{1}{2.24} \Rightarrow \boxed{0.446}$

③ PV array = 2
Insolution =

Daily Energy =
= 8
In a year = 8.8
= 3212

$\eta = 12\%$
Insolution = 6 kWh /
PV = 4×10^{12} W
Energy got = $\frac{12}{100} \times$
Energy = 4×10^{1}
= Demanded / Generated

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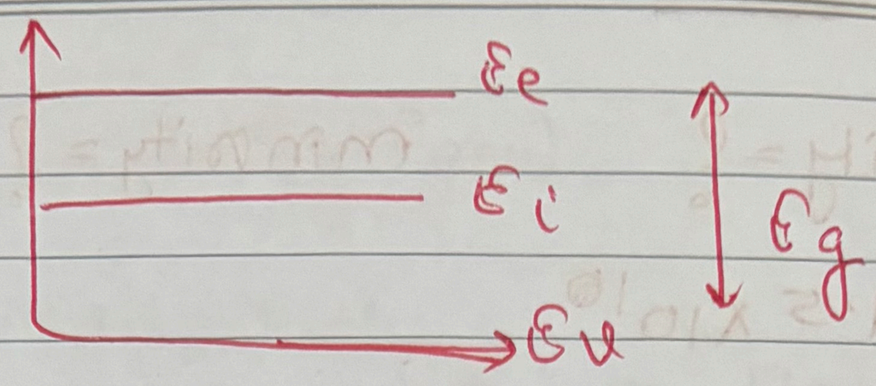
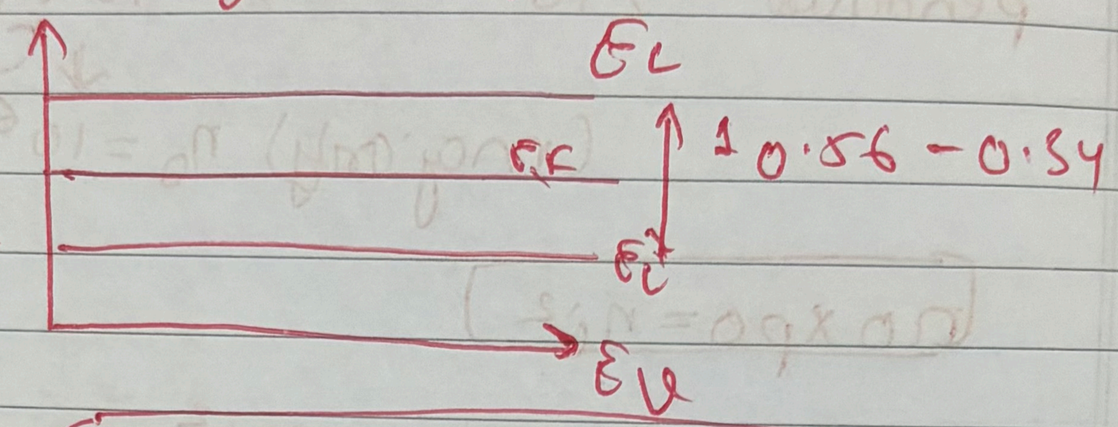
Ans3:→



$E_i = \frac{E_g}{2} \Rightarrow \frac{1.12}{2} \Rightarrow 0.56$



$$\boxed{n_0 = n_i \times e^{\left(\frac{E_F - E_i}{KT}\right)}}$$

$E_F - E_i \Rightarrow \frac{KT}{q} \ln\left(\frac{N_D}{N_i}\right)$ eV

$\Rightarrow 0.256 \times \ln\left(\frac{10^6}{1.5 \times 10^{10}}\right)$

$\Rightarrow 0.34$ eV

Remay $\Rightarrow$ $0.56 - 0.34 \Rightarrow 0.23$

Ans4:→

$n_1 = 10^{17}$
$n_2 = 10^{15}$
$x \Rightarrow 100\ \mu m$
$D_n = 30\ cm^2/s$

$$\boxed{I = q D_n \cdot \frac{dn}{dx}}$$

②

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$$I = 1.6\times10^{-19} \times 30 \times \frac{(n_2 - n_1)}{\tau}$$

$$\Rightarrow 1.6\times10^{-9} \times 30 \times \frac{(10^{17} - 10^{15})}{100\times10^{-6}}$$

$$\boxed{I \Rightarrow 4.75\ A/cm^2}$$

Ans:→ $\alpha = 10^4/cm^2$

$$\boxed{L = \frac{1}{\alpha}}$$

$$L = \frac{1}{10^4} \approx 10^{-4}\ cm^2$$

Ans:→ $L_D = ?$

$\mu_n = 1250\ cm^2/Vs$

$\tau_n = 10^{-6}$

$$\boxed{L_D = \sqrt{D\tau_n}}$$

$$\boxed{D = \frac{\mu_n kT}{q}}$$

$$\Rightarrow 1250 \times 25.8\ meV$$

$$L_D = \sqrt{1250 \times 25.8 \times 10^{-6}}$$

$$\boxed{L_D = 17.6\ cm^2}$$

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Ans 7: →

$n_1 \Rightarrow 10^3 \ /cm^3$

$n_2 \Rightarrow 10^{16} \ /cm^2$

$x = 2\mu m$

$t = 2\mu s$

Recombination Rate = ?

$$\boxed{R = \frac{\Delta n}{t}}$$

$$R = \frac{\Delta n}{t} \Rightarrow \frac{n_2 - n_1}{2\mu s} \Rightarrow \frac{10^{16} - \overset{\text{ign.}}{10^3}}{2 \times 10^{-6}}$$

$$\boxed{R \Rightarrow 5 \times 10^{21} / m^3}$$

Ans 8: →

$x = 0.46 \ \mu m$

$\alpha = 5 \times 10^4 \ /m$

$I_0 = 10 mW$

$I = ?$

$$\boxed{I = I_0 e^{(-\alpha x)}}$$

$$I = 10 \times 10^{-3} \exp\left(5 \times 10^4 \times 0.46 \times 10^{-6} \times (-1)\right)$$

$$I \Rightarrow 10^{-2} \exp(0.023)$$

$$I \Rightarrow 10^{-2} \times 1.02$$

$$\boxed{I \Rightarrow 1 mW}$$

$$\boxed{P_{absorbed} = 10 - 1 = 9 mW}$$

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If photons asked

$$E = \frac{hc}{\lambda} \times n$$

$$\boxed{E = nh \cdot \nu}$$

$\nu \rightarrow$ frequency.

Ans :→ $\tau = 10^{-7} sec$

$\mu_n = 0.15 \ m^2/vs$

$T = 300K$

$$D = \frac{\mu K T}{q}$$

(a) $\boxed{L = \sqrt{D\tau}}$

$$D = \mu \times 25.6$$

$$L = \sqrt{0.15 \times 25.6 \times 10^{-9}}$$

$$\boxed{L = 1.96 \times 10^{-5}}$$

(b) $n = 10^{20}$ at $x = 0$

$J = ?$ at $x = 0$

$$\boxed{J_n = q \times D_n \times \frac{dn}{dx}}$$

$$\Rightarrow q \times D_n \times \frac{(10^{20} - 0)}{L_n}$$

$$\boxed{J_n \Rightarrow 3.16 \times 10^{3}} \ A/m^2$$

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$\phi_1 \Rightarrow \frac{\text{frequency}}{E_g}$

$E = h\nu$

$\phi_2 = \frac{f_2}{E_{g_2}}$

$J_{SC} \Rightarrow qA(\phi_1 + \phi_2)$

$V_{OC} \Rightarrow \frac{KT}{q} \ln\left(\frac{J_{sc}}{J_0} + 1\right)$

$J_{SC_1} \Rightarrow qA\phi_1$

$J_{SC_1} = qA\phi_2$

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Tut-3

Ans 2 :⇒

$V_{oc_1} = 0.5\,V$ $\qquad$ $V_{oc_2} = 0.6\,V$

$I_{sc_1} = 15\,mA$ $\qquad$ $I_{sc_2} = 10\,mA/m^2$

V_{oc} & $I_{sc} = ?$

In parallel :-

$$J = J_{sc_1} + J_{sc_2}$$
$$= 15 + 10$$
$$\boxed{J = 25\,mA/m^2}$$

$$I_{sc} = I_0\left[\exp\left(\frac{qV}{kT}\right) - 1\right]$$

I_{01} & I_{02} (आजाएगा)

At short ckt $\quad V = 0$

$$V_1 + V_2 = V_1 + V_2$$
$$[V_1 = V_2]$$

at $V = V_{oc}$

$$I_1 = -I_2$$

$$V_{oc} = \frac{kT}{q}\ln\left[\frac{I_{sc_1} + I_{sc_2} + \cdots I_{sc_n}}{I_{01} + I_{02} + \cdots I_{0n}} + 1\right]$$

$$V_{oc} = 0.512\,V$$

1.0×10^{-23}

$\frac{kT}{q} =$ $\quad$ $300\,K$

$25.6\,mV$

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Ans 3:→ $T = 27^\circ C$

$J_{sc} = 20\,mA$

$J_0 = 10^{-9}\,mA$

$FF = 0.75$

$n = ?$

$V_{oc} = ?$

$$\therefore V_{oc} = \frac{kT}{q} \ln\left[\frac{J_{sc}}{J_0} + 1\right]$$

$$\therefore n = \frac{V_{oc} \times J_{sc} \times FF}{P_{in}}$$

(AM1.5G)

Ans 4:→ $A = 100\,cm^2$

$P_{o_1} = 4000\,W/m^2$ $\quad$ $P_{o_2} = 8000\,W/m^2$

$E_{g_1} = 1.5\,eV$ $\quad$ $E_{g_2} = 2\,eV$

$J_0 = 10^{-10}$ $\quad$ $J_0 = 10^{-10}$

$$\therefore J_{sc_1} = \frac{P}{E_{g_1}} \qquad \therefore J_{sc_2} = \frac{P_{o_2}}{E_{g_2}}$$

$$\therefore V_{oc_1} = \frac{kT}{q} \ln\left[\frac{J_{sc_1}}{J_{0_1}} + 1\right]$$

(put the values)

$$\therefore V_{oc_2} = \frac{kT}{q} \ln\left[\frac{J_{sc_2}}{J_{0_1}} + 1\right]$$

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Ans: $J = 350\ A/m^2$
$T = 300\ K$
$N_i = 1.5 \times 10^{10}/cm^2$
$N_A = 10^{11}\ atm/cm^2$
$N_D = 10^{19}\ atm/cm^2$
$\mu_n = 500\ \mu n$ $\qquad \mu_n = 1000$
$\mu_p = 10\ \mu n$ $\qquad \mu_p = 100$

doping case:-

(a) $V_b = \frac{KT}{q} \ln\left[\frac{N_A N_D}{(N_i)^2}\right]$

(b) $V_{oc} = V_b + \frac{KT}{q} \ln\left[\frac{J_{sc}}{J_0} + 1\right]$ — J_{sc}: 350 (given)

$$J = J_0 \left[\exp\left[\frac{qV}{KT} - 1\right]\right]$$

$$J_0 = \frac{q n^2}{L_p U_p + L_n \cdot U_n}$$

$V_{oc_N} = \frac{q}{AKT} \times V_{oc}$

(c) $\eta = \frac{V_{oc} \times J_{sc} \times F.F}{P_{in}}$ (P_{in}: AM1.5)

$$FF = \frac{V_{oc} - \ln(V_{oc} + 0.72)}{V_{oc} + 1}$$

Pattern above

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Ans ⇒ $\boxed{J \propto \frac{I_{sc}}{2}}$

⇒ $\boxed{V_{oc_1} = \frac{KT}{q} \ln\left[\frac{J_{sc_1}}{J_0}\right]}$

$V_{oc_2} = \frac{KT}{q} \ln\left[\frac{J_{sc_2}}{J_0}\right]$

$V_{oc_1} - V_{oc_2} = \frac{KT}{q} \ln\left[\frac{J_{sc_2}}{J_{sc_1}}\right]$

$\boxed{V_{oc_2} = V_{oc_1} - KT \ln\left[\frac{1}{2}\right]}$

$\boxed{F.F = \frac{J_{mp} \times V_{mp}}{J_{sc} \times V_{oc}}}$