1) $P_{t+3} = 2\,P_t = \underbrace{\underbrace{P_t \times a}_{P_{t+1}} \times a}_{P_{t+2}} \times a \Rightarrow a^3 = 2$

$\Rightarrow a = \sqrt[3]{2}$

$P_{2020} = P_{2012} \times a^8 = 635 \text{ GW}$

$P_{2050} = P_{2012} \times a^{38} = 650 \times 10^3 \text{ GW}$

$C_{t+3} = 0{,}8\,C_t = C_t \times b^3 \Rightarrow b = \sqrt[3]{0{,}8}$

$C_{2020} = C_{2012} \times b^8 = 0{,}13 \text{ €/kWh}$

$C_{2050} = C_{2012} \times b^{38} = 0{,}01 \text{ €/kWh}$

2) O $\lambda$ que otimiza a produção é aquele cujos fotões têm exatamente a energia do hiato

$E_g = 1{,}4 \text{ eV} = 1{,}4 \times 1{,}60 \times 10^{-19} = 2{,}24 \times 10^{-19} \text{ J}$

$E = \frac{hc}{\lambda} \Leftrightarrow \lambda = \frac{6{,}63 \times 10^{-34} \times 3 \times 10^8}{2{,}24 \times 10^{-19}} = 8{,}88 \times 10^{-7} \text{ mm}$

$\Rightarrow 888 \text{ nm}$

3) a) $ff = \frac{I_{MPP} \times V_{MPP}}{I_{SC} \times V_{OC}} = \frac{2{,}91 \times 0{,}48}{3{,}15 \times 0{,}59} = 0{,}75$

$A = 0{,}01 \text{ m}^2 \Rightarrow P_{incidente} = 10 \text{ W}$

$\eta = \frac{I_{MPP} \times V_{MPP}}{P_{incidente}} = 14\,\%$

b)

b) Em curto-circuito : $V = 0$

$$\Rightarrow I = I_s - I_0 (1-1) = I_s = 3{,}15\ A$$

Em circuito aberto : $I = 0$

$$\Rightarrow I_s = I_0 \left( \exp\left(\frac{V}{m V_T}\right) - 1 \right) \approx I_0 . \exp\left(\frac{V}{m V_T}\right)$$