① $V = 500\ dm^3 = 0.5\ m^3$

$p = 200\ Pa$

$t = 20°C \Rightarrow T = 293K$

$M = 1\ g/mol = 1 \cdot 10^{-3}\ kg/mol$ u ATOMSKOM STANJU (H)

a) $m = ?$ ↳ treba nam molekulsko, $\times 2$ H_2

b)

a) $pV = Nk_BT = nRT = \frac{m}{M}RT \Rightarrow m = \frac{pVM}{RT}$

(N: br čestica; k_B: boltzmanova konst; M: molarna masa)

$R = 8.314\ J/mol\,K$

Avogadrov broj: $N_A = 6.02 \cdot 10^{23}\ mol^{-1}$

$M = 2 \cdot (1 \cdot 10^{-3}\ kg/mol)$

$$\boxed{m = 8.21 \cdot 10^{-5}\ kg}$$

b) $N = ?$ $\quad n = \frac{m}{M} = \frac{N}{N_A} \Rightarrow N = N_A \frac{m}{M} = 2.47 \cdot 10^{22}$

ubject :

(2) $n = 10^{18}\ m^3$

$k_B T_e = 0.517\ eV$ → termalna energija elektrona
(pretvarat u J kod korištenja formula)

$k_B T_e = 0.517 \cdot 1.6 \cdot 10^{-19}\ J = 8.272 \cdot 10^{-20}\ J$

$e = 1.6 \cdot 10^{-19}\ C$

$m_e = 9.11 \cdot 10^{-31}\ kg$

$\varepsilon_0 = 8.85 \cdot 10^{-12}\ F/m$

a) $\omega_{pe} = ?$ plazmena frekv.

$$\omega_{pe} = \sqrt{\frac{ne^2}{m_e \varepsilon_0}} = \sqrt{\frac{10^{18} \cdot (1.6 \cdot 10^{-19})^2}{}}$$

$$\boxed{\omega_{pe} = 5.634 \cdot 10^{10}\ s^{-1}}$$

b) $\lambda_D = ?$

$$\lambda_D = \sqrt{\frac{\varepsilon_0 k_B T_e}{ne^2}} = \sqrt{\frac{8.85 \cdot 10^{-12} \cdot 8.272 \cdot 10^{-27}}{10^{18} \cdot (1.6 \cdot 10^{-19})^2}}$$

$$\boxed{\lambda_D = 5.347 \cdot 10^{-6}\ m}$$

c) $N_D = ?$

$$N_D = \frac{4}{3} \pi \lambda_D^3 n$$

$$\boxed{N_D \approx 640}$$

Subject :

③ $k_B T_e = k_B T_i = 800\,eV = 800 \cdot 1.6 \cdot 10^{-19}\,J = 1.28 \cdot 10^{-16}\,J$

$n_0 = 10^{23}\,m^{-3}$

$\nu_{ei} = ?$

$e = 1.6 \cdot 10^{-19}\,C$

$m_e = 9.11 \cdot 10^{-39}\,kg$

$\varepsilon_0 = 8.85 \cdot \cdot$

$$\nu_{ei} = \frac{n_0 e^4 \overbrace{\ln(12\pi N_D)}^{15.35}}{32\sqrt{\pi m_e}\,\varepsilon_0^2 (2k_B T_e)^{\frac{3}{2}}}$$

$$N_D = \frac{4\pi}{3} \lambda_D^3 n_0$$

$$\lambda_D = \sqrt{\frac{\varepsilon_0 k_B T_e}{n_0 e^2}} = 6.652 \cdot 10^{-7}\,m$$

$N_D = 1.23 \cdot 10^5$

$$\boxed{\nu_{ei} = 5.79 \cdot 10^7\,s^{-1}}$$

b) $\sigma = ?$

$$\sigma = \frac{16\pi m_e \varepsilon_0^2 (k_B T_e)^{\frac{3}{2}}}{\sqrt{m_e}\, e^2} = \underline{\underline{2.126 \cdot 10^{-22}\,S}}$$

Subject : Date :...../...../...

(4) $n_0 = 10^{12}\,cm^{-3} = 10^{18}\,m^{-3}$ gustoća

$k_B T = 5\,keV = 8 \cdot 10^{-16}\,J$

$\nu_{ei} = 2.8 \cdot 10^7\,s^{-1}$

$\nu_{ee} = 1.4 \cdot 10^7\,s^{-1}$

$m_e = 9.11 \cdot 10^{-31}\,kg$

$\lambda_{SSD} = ?$

$\lambda_{SSD} = \frac{v_t}{\nu}$

$\frac{m v_t^2}{2} = \frac{k_B T}{2}$ → za 1 stupanj slobode

$\lambda_{SSP} = \frac{1}{\nu_{ee} + \nu_{ei}} \sqrt{\frac{k_B T}{m_e}}$

$v_t = \sqrt{\frac{k_B T}{m_e}}$

$\boxed{\lambda_{SSP} = 0.706\,m}$

(5) $r_L = 7 \cdot 10^{-5}\,m$

$B = 5\,T$

a) $v = ?$

b) $\Omega = ?$

$q \vec{v} \times \vec{B}$ → mag je okomito

$qvB \sin\theta$ $\sin 90^\circ = 1$

centripetalna Lorentzova

$\frac{m v^2}{r} = qvB$

$q = e = 1.6 \cdot 10^{-19}\,C$

$r = r_L$

$m = m_e = 9.11 \cdot 10^{-31}\,kg$

$v = \frac{e B r_L}{m_e}$

$\boxed{v = 6.15 \cdot 10^7\,m/s}$

$\Omega = \frac{qB}{m} = \frac{eB}{m_e} =$

$\boxed{\Omega = 8.78 \cdot 10^{11}\,s^{-1}}$

(6) $n_e - T_e$ prostor

jdba. prostora $\frac{T_e^{3/2}}{n_e} = \frac{(\hbar/2)^3}{(3 m_e k)^{\frac{3}{2}}}$ / . $k^{\frac{3}{2}}$

$kT_e = 4\ keV = 6.4 \cdot 10^{-16}\ J$

$n_0 = 10^{14}\ cm^{-3} = 10^{20}\ m^{-3}$

$\frac{(kT_e)^{\frac{3}{2}}}{n_e} = \frac{(\frac{\hbar}{2})^3}{(3m_e)^{\frac{3}{2}}}$

$\hbar = \frac{h}{2\pi}$ REDUCIRANA PLANCKOVA KONST.

$h = 6.626 \cdot 10^{-34}\ J\,s$ → PLANCKOVA KONST.

$m_e = 9.11 \cdot 10^{-31}\ kg$

$\frac{(6.4 \cdot 10^{-16})^{\frac{3}{2}}}{10^{20}} = 1.62 \cdot 10^{-43}$

$\frac{(\frac{\hbar}{2})^3}{(3m_e)^{\frac{3}{2}}} = \frac{(\frac{h}{2\pi} \cdot \frac{1}{2})^3}{(3m_e)^{\frac{3}{2}}}$

$= 0.0323 \cdot 10^{(-102-(-45))} = 0.0323 \cdot 10^{-57}$

$= 3.23 \cdot 10^{-59}$

Kvantni efekti izraženiji kako temp. pada, a gustoća raste (npr. metali)

Subject : Date :...../...../.....

gustoća broja ioniziranih čestica

(7) $\frac{n_i}{n_n} \approx 2.4 \cdot 10^{21} \frac{T^{\frac{3}{2}}}{n_i} e^{\frac{-U_i}{kT}}$

n_n → neutralne

stupanj ionizacije $U_i = 14.5\,eV =$

$T = 300\,k$

energija ionizacije
↳ energija potrebna da se izbije (izvuče) čestica

$1eV = 1.6 \cdot 10^{-19}\,J$

$k = 1.38 \cdot 10^{-23}\,J/k$

↳ $1ev \sim 11\,600\,k$

$300\,k : 11\,600k = x : 1eV$

$x = 0.0259\,eV$

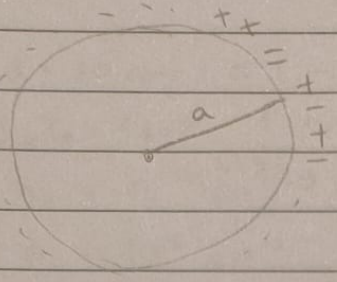
$\frac{n_i}{n_n} \approx 2.4 \cdot 10^{21} \cdot \frac{300^{\frac{3}{2}}}{n_i} e^{\frac{-14.5eV}{0.0259eV}}$

$e^{-560} = (e^{-56})^{10}$

$\frac{n_i}{n_n} \approx 10^{-122}$

↳ nije plazma

(8)



JEDNOSTRUKA IONIZACIJA
IONI NEPOKRETNI
ELEKTRONI SE GIBAJU

$n_i = n_0$ $\qquad k_B T_e >> e\phi$

$n_e = n_0 e^{\frac{e\phi}{k_B T_e}}$ $\qquad n_e \approx n_0 \left(1 + \frac{e\phi}{k_B T_e}\right)$

$$\rho = e(n_i - n_e) = e\left(n_0 - n_0 - n_0 \frac{e\phi}{k_B T_e}\right) = -\frac{n_0 e^2 \phi}{k_B T_e}$$

POISSONOVA JDBA

$$\nabla^2 \phi = -\frac{\rho}{\varepsilon_0} \qquad \text{JER} \quad \vec{\nabla} \cdot \vec{E} = \frac{\rho}{\varepsilon_0}$$

$$\vec{E} = -\vec{\nabla}\phi$$

$$\nabla^2 \phi = \frac{-\rho}{\varepsilon_0} = -\frac{1}{\varepsilon_0}\left(\frac{-n_0 e^2 \phi}{k_B T_e}\right)$$

$$\nabla^2 \phi = \frac{n_0 e^2}{\varepsilon_0 k_B T_e}\phi \quad , \lambda_D = \sqrt{\frac{\varepsilon_0 k_B T_e}{n_0 e^2}}$$

$$\nabla^2 \phi = \frac{1}{\lambda_D^2}\phi \rightarrow \nabla^2 \phi - \frac{1}{\lambda_D^2}\phi = 0 \qquad \text{JDBA ZA } \phi$$

$$\phi = \frac{A}{r} e^{-r/\lambda_D} + \frac{B}{r} e^{r/\lambda_D}$$

POČ. UVJETI

$r \rightarrow \infty$, $\phi \rightarrow 0$ $\Rightarrow B = 0$

$r \rightarrow a$, $\phi \rightarrow \phi_s$ ili $\phi_s = \frac{A}{a} e^{-a/\lambda_D} \Rightarrow A = \frac{a\phi_s}{e^{-a/\lambda_D}}$

$$A = a\phi_s e^{\frac{a}{\lambda_D}}$$

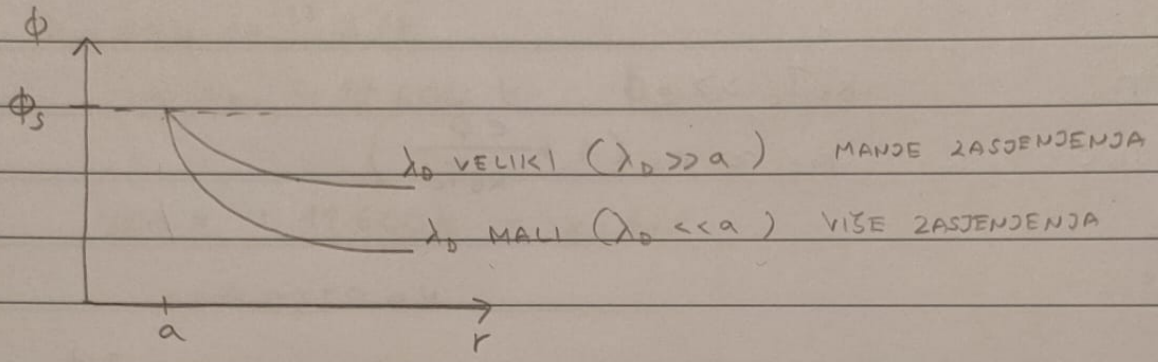
KON. RJ

$$\phi = \frac{A}{r} e^{-r/\lambda_D} = a\phi_s e^{a/\lambda_D} e^{-r/\lambda_D}$$

b) $\lambda_D << a \Rightarrow \phi = \frac{a\phi_s}{r} e^{a/\lambda_D} e^{-r/\lambda_D}$

$\lambda_D >> a \Rightarrow \phi = \frac{a\phi_s}{r} \underbrace{e^{a/\lambda_D}}_{\approx 1} e^{-r/\lambda_D} = \frac{a}{r}\phi_s e^{-r/\lambda_D}$

$\lambda_D = \sqrt{\frac{\varepsilon_0 k_B T_e}{n_0 e^2}}$



c) $\iint_S \vec{E} \cdot d\vec{S} = \frac{A}{\varepsilon_0} \iiint_V \vartheta dV$

$E \cdot 4a^2\pi = \frac{Q_{SFERE}}{\varepsilon_0}$

$E = -\frac{\partial \phi}{\partial r} = -\left(-\frac{a}{r^2}\phi_s e^{a/\lambda_D} e^{-r/\lambda_D} + \frac{a}{r}\phi_s e^{a/\lambda_D} e^{-r/\lambda_D} \cdot \left(-\frac{1}{\lambda_D}\right) \right)$

$= \frac{a}{r^2}\phi_s e^{a/\lambda_D} e^{-r/\lambda_D} \left(1 + \frac{r}{\lambda_D}\right)$ → izgled el. polja

$Q_{SFERE} = 4a^2\pi\varepsilon_0 E(a)$ ($e^0 = 1$)

$= 4a^2\pi\varepsilon_0 \left(\frac{a}{a^2}\phi_s e^{a/\lambda_D} e^{-a/\lambda_D} \cdot \left(1 + \frac{a}{\lambda_D}\right) \right)$

$= 4\pi\varepsilon_0 a \phi_s \left(1 + \frac{a}{\lambda_D}\right)$

KAPACITET

$C = \frac{Q}{V} = \frac{4\pi\varepsilon_0 a \phi_s \left(1 + \frac{a}{\lambda_D}\right)}{\phi_s - \phi_\infty} = 4\pi\varepsilon_0 a \left(1 + \frac{a}{\lambda_D}\right)$

($\phi_\infty \to 0$)

bject : Date :..

d) $a = 10\ cm = 0.1\ m$

$k_B T_e = 1\ keV = 1 \cdot 10^3\ eV = 10^3 \cdot 1.6 \cdot 10^{-19}\ J$

1) $n_0 = 10^{14}\ cm^{-3}$

2) $n_0 = 10^{6}\ cm^{-3}$

USPOREDITI S C U VAKUUMU

$$\lambda_D = \sqrt{\frac{\varepsilon_0 k_B T_e}{n_0 e^2}}$$

① $\lambda_D >> a \Rightarrow C = 4\pi\varepsilon_0 a \left(1 + \frac{a}{\lambda_D}\right)$ ↑ ↳ zanemarivo

$C = 4\pi\varepsilon_0 a$

② $\lambda_D << a \Rightarrow C = 4\pi\varepsilon_0 a \left(1 + \frac{a}{\lambda_D}\right) = \frac{4\pi\varepsilon_0 a^2}{\lambda_D}$ ↓ zanemarivo

1) $\lambda_D = 2.35 \cdot 10^{-3}\ cm \Rightarrow C = 4.7 \cdot 10^{-8}\ F$

2) $\lambda_D = 23.4\ cm \Rightarrow C = 1.6 \cdot 10^{-11}\ F$

$$C = \frac{Q}{V} \qquad \Phi_S = \frac{Q}{4\pi\varepsilon_0 a}$$

$$C = \frac{\Phi_S\ 4\pi\varepsilon_0 a}{\Phi_S}$$

$$C = 4\pi\varepsilon_0 a = 1.11 \cdot 10^{-11}\ F$$

① KRATKA λ_D → velika n_0 $\left(\lambda_D^2 \sim \frac{1}{n_0}\right)$ => DIELEKTRIK

②

↳ u zadacima je najčešće zadan potencijal