NPRE 321 HW 1

James Liu

Due: Sep 25 Edit: September 23, 2024

1. i: $\lambda_D = \sqrt{\dfrac{\varepsilon_0 kT}{ne^2}} = \sqrt{\dfrac{8.854 \times 10^{-12} \times 3 \times 11604 \times 1.38 \times 10^{-23}}{10^{17} \times (1.62 \times 10{-}19)^2}} = \boxed{4.071 \times 10^{-5}\ \mathrm{m}}$

   ii: $\dfrac{4}{3}\pi\lambda_D^3 = \dfrac{4}{3} \times 3.1415 \times (4.071 \times 10^{-5})^3 = 2.826 \times 10^{-13}\ \mathrm{m}^3$
   $nV = 10^{17} \times 2.826 \times 10^{-13} = \boxed{28263.272}$

2. i: setting $\begin{cases} \rho = 10^{20}\ \mathrm{m}^{-3} \\ T = 10^3\ \mathrm{eV} \end{cases}$ As environment in magnectic fusion experiment, while setting it to hydrogen plasma.
   $\lambda_D = 7430\sqrt{\frac{T}{n}} = 2.35 \times 10^{-5}$ m
   $\omega_e = \sqrt{\frac{n_e e^2}{\varepsilon_0 m_e}} = 5.64 \times 10^{11}$
   $\omega_i = \sqrt{\frac{n_i e^2}{\varepsilon_0 m_i}} = 1.31627 \times 10^{10}$
   $f_e = \omega_e/2\pi = 8.976 \times 10^{10}$
   $f_i = \omega_i/2\pi = 2.094 \times 10^9$

   ii: setting $\begin{cases} \rho = 10^{25}\ \mathrm{m}^{-3} \\ T = 10^5\ \mathrm{eV} \end{cases}$ As environment in magnectic fusion reactors, while setting it to hydrogen plasma.
   $\lambda_D = 7430\sqrt{\frac{T}{n}} = 7.43 \times 10^{-7}$ m
   $\omega_e = \sqrt{\frac{n_e e^2}{\varepsilon_0 m_e}} = 1.78 \times 10^{14}$
   $\omega_i = \sqrt{\frac{n_i e^2}{\varepsilon_0 m_i}} = 4.1624 \times 10^{12}$
   $f_e = \omega_e/2\pi = 2.832 \times 10^{13}$
   $f_i = \omega_i/2\pi = 3.332 \times 10^{11}$

   iii: setting $\begin{cases} \rho = 10^{7}\ \mathrm{m}^{-3} \\ T = 10\ \mathrm{eV} \end{cases}$ As environment in solar wind, while setting it to hydrogen plasma.
   $\lambda_D = 7430\sqrt{\frac{T}{n}} = 7.43$ m
   $\omega_e = \sqrt{\frac{n_e e^2}{\varepsilon_0 m_e}} = 1.78 \times 10^{5}$
   $\omega_i = \sqrt{\frac{n_i e^2}{\varepsilon_0 m_i}} = 4.16 \times 10^{3}$

$f_e = \omega_e/2\pi = 2.83 \times 10^4$
$f_i = \omega_i/2\pi = 662.085$

3.

$$\oint Bdl = \mu_0 \sum I$$
$$B \times 2\pi r = \mu_0 NI$$
$$B = \frac{\mu_0 NI}{2\pi r}$$

4. i: $1 \times 10^4 \times e \times 1 = \boxed{1.602 \times 10^{-15} \text{ J}}$

ii: $10^4 \times 11604 = \boxed{1.16 \times 10^8 \text{ K}}$

iii: $v = \sqrt{\frac{8KT}{\pi m}} = \boxed{1.561 \times 10^6 \text{ m/s}}$

5.

i: $v_i = \sqrt{\frac{8KT_i}{\pi m_i}} = \sqrt{\frac{8\times1.38\times10^{-23}\times100\times11604}{1.008665\times1.673\times10^{-27}}} = \boxed{2.755 \times 10^5 \text{ m/s}}$
$v_e = \sqrt{\frac{8KT_e}{\pi m_e}} = \sqrt{\frac{8\times1.38\times10^{-23}\times1000\times11604}{9.11\times10^{-31}}} = \boxed{3.74998 \times 10^7 \text{ m/s}}$

ii: $\omega_e = \sqrt{\frac{n_e e^2}{\varepsilon_0 m_e}} = \sqrt{\frac{10^{17}\times(1.602\times10^{-19})^2}{8.854\times10^{-12}\times9.11\times10^{-31}}} = \boxed{1.784 \times 10^{10}}$
$\omega_i = \sqrt{\frac{n_e e^2}{\varepsilon_0 m_i}} = \sqrt{\frac{10^{17}\times(1.602\times10^{-19})^2}{8.854\times10^{-12}\times1.673\times10^{-27}}} = \boxed{4.1624 \times 10^8}$

iii: $f_e = \frac{\omega_e}{2\pi} = 2.8397 \times 10^9$ Hz $= 2839.7$ MHz
$f_i = \frac{\omega_I}{2\pi} = 6.6247 \times 10^7$ Hz $= 66.247$ MHz Thus, it will be heating ions.

iv: $f = \frac{Bq}{2\pi m} = 7.6 \times 10^7 = \frac{B\times1.602\times10^{-19}}{2\pi1.673\times10^{-27}}$, Thus, $B = \boxed{4.98686 \text{ T}}$

v: $r_i = \frac{v_i}{\omega_i} = \frac{2.755\times10^5}{4.1624\times10^8} = \boxed{6.6187 \times 10^-4 \text{ m}}$