NPRE 321: Introduction to Plasmas and their Applications

Homework 1.

Constants

$m_e = 9.11\times10^{-31}$ kg

$u = 1.673\times10^{-27}$ kg

$c = 2.998\times10^{8}$ m s^{-1}

$e = 1.602\times10^{-19}$ C

$k_B = 1.38\times10^{-23}$ m^{2}kg s^{-2}K^{-1}

$N_{AV} = 6.022\times10^{23}$ mole^{-1}

$\mu_0 = 4\pi\times10^{-7}$ m kg s^{-2}A^{-2}

$\varepsilon_0 = 8.854\times10^{-12}$ m^{-3}kg^{-1}s^{4}A^2

H = 1.000000u

D = 2.013553u

T = 3.015501u

^{4}***He*** = 4.001503u

n = 1.008665u

$N_{tor} = 40$

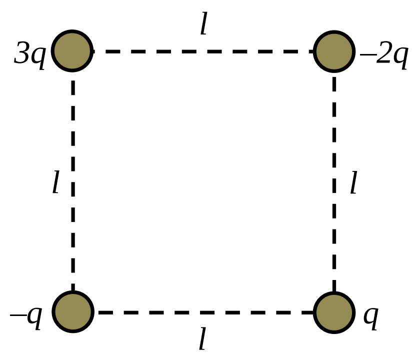
$N_{hel} = 4$

1 eV = 11604 K

Make sure to show all working including and diagrams

(1): write about half a page on what do you understand a plasma to be? Where is plasma used on earth and where does it exist in the universe? This will require you to do a bit of research. **(10 marks)**

(2): Consider four charges that sit at the corner of a square. The sides of the square are, $l = 5$ cm in length. The upper right hand corner has a charge of $-2q$, the lower right has a charge of q, the lower left a charge of $-q$ and the upper left a charge of $3q$. Find the magnitude of the force exerted on the charge at the lower left corner of



the system assuming that $q = 1.0\times10^{-6}$ C. **(10 marks)**

(3): An insulating sphere has a diameter of 2 cm and an overall charge density ρ = 2.4 Cm^{-3}. (a) Find what the electric field is when the diameter is half the as big as the sphere, (b) the electric field at the surface of the sphere and (c) the electric field 5 cm from the surface of the sphere. **(8 marks)**

(4): An electron enters a uniform magnetic field which is perpendicular to its motion. It has a temperature of 100,000 K. (a) Describe what will happen to the electron within the magnetic field, (b) what is the gyro-frequency of the electron if the B–field has a strength of $B = 1$ T and (c) what is the radius of the motion. **(12 marks)**

<u>Hint:</u> You may want to use, $E = \frac{1}{2} mv^2$ and $E = k_B T$

(5): When a magnetic field exists, it will produce a magnetic pressure. Assuming that there is no electric field present and starting with

$$\boldsymbol{F} = q(\boldsymbol{E} + \boldsymbol{v} \times \boldsymbol{B})$$

$$\boldsymbol{\nabla} \times \boldsymbol{B} = \mu_o \boldsymbol{J} + \mu_0 \varepsilon_0 \frac{\partial \boldsymbol{E}}{\partial t}$$

Find the relationship for the magnetic pressure

$$p = \left| \frac{B^2}{2\mu_0} \right|$$

<u>Hint:</u> use the relation $(B \cdot \nabla)B = \nabla\left(\frac{1}{2}B^2\right) - B \times (\nabla \times B)$ **(10 marks)**