PHYS-207(5) (Kaldon-19884) **Name** ____

WMU-Fall 2001 **Book Title** ____

Exam 00 - 000,000 points + 00,000 ☆ points

Sample – Not a Real Exam

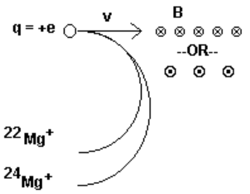
Rev. 9/30/2001 Su

State Any Assumptions You Need To Make – Show All Work – Circle Any Final Answers
Use Your Time Wisely – Work on What You Can – Be Sure to Write Down Equations
Feel Free to Ask Any Questions ☐☆3a ☐☆3b ☐☆3c ☐☆3e

Magnesium Hits On The Ol' Mass Spectrometer (25,000 points)

1.) A desktop mass spectrometer is going to be used to separate two magnesium isotopes. (a) Mg^+ ions, moving at $\vec{v} = 125\ m/s\ \hat{i}$, safely pass through two velocity selectors. The first has $\vec{B} = -1500\ T\ \hat{k}$, the second has
$\vec{E} = +1500\ N/C\ \hat{k}$. Find the $\vec{E}$ and $\vec{B}$, respectively, of the two velocity selectors.

(b) We design the mass spectrometer so that $^{22}Mg^+$ ions (mass = $22 \times 1.7 \times 10^{-27}\ kg$) will travel in a semi-circle of *diameter* D = $0.305\ m$ (one foot). Find the magnetic field vector, $\vec{B}$, that will do this.



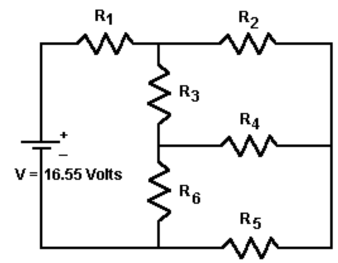
(c) Use the magnetic field vector, $\vec{B}$, from (b) to determine the *diameter* of the path of any $^{24}Mg^+$ ions that happen to enter the mass spectrometer.

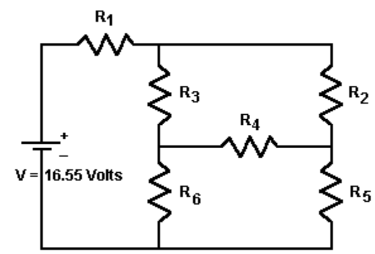
(d) What is the separation distance, *d*, between the $^{22}Mg^+$ and $^{24}Mg^+$ ions after they have traveled around their semi-circles? Is this separation large enough to measure on film, filter paper or electronic detector?

(e) If a trillion Mg^+ ions go through the mass spectrometer every second, what current, i, does this represent?

"Resistance is Futile", "Resistance is Irrelevant" The Borg -- Star Trek: Next Generation (25,000 points)

2.) The circuit on the left is the same as the circuit that showed up in Quiz # 9[†], except that there is a new resistor at R_6. The same circuit is redrawn at the right for clarity. You'd think that you could solve this using network reduction, but trust Dr. Phil, you can't. Given that all the resistors are 125 Ω, however, you <u>can</u> find an equivalent resistance if you realize that the current through R_4, $I_4 = 0$. (a) Why is $I_4 = 0$?





(b) Find R_{TOTAL} and (c) I_{TOTAL} for the circuit.

(d) Find the currents through all the resistors (I_1, I_2, I_3, I_5 and I_6) given that $I_4 = 0$.

(e) Treating all the currents through the resistors (I_1, I_2, I_3, I_4, I_5 and I_6) as unknowns, write down *but do not solve* all the equations you need to solve this circuit as a multi-loop circuit (Kirchhoff's Laws). Note which ones would show that $I_4 = 0$.

[†] From PHYS-207 Summer 1995.

Odds & Ends: Mostly Odd, Mostly Math (25,000 points)

3.) ☆(a) An RC circuit has a time constant of $RC = 1.00\ s$. If the initial charge was $q_0 = 1.00 \times 10^{-5}\ C$, find the time t where the remaining charge is equal to the last electron: $q(t) = e$. (After this ±e charge leaves the two plates, $q(t) = 0$, so it does not take an infinite amount of time to discharge a capacitor.)

A spherical conductor of radius $R = 0.100\ m$ and charge $Q = 1.38 \times 10^{-3}\ C$ has the electric field of a point charge outside the sphere, and $\vec{E} = 0$ inside. Find the potential V(r) for ☆(b) r > R and ☆(c) r < R, using: $\Delta V = V_f - V_i = -\int_i^f \vec{E} \cdot d\vec{s}$. Choose $V = 0$ at $r = \infty$.

Finding the resistance R of a truncated cone of length L and radii a and b (where $a > b$), turns out to be a horrible problem. However, assuming that the current density, $\vec{J}$, is constant over any circular cross-sectional slice of the object, you can easily write down expressions for (d) the current density $\vec{J}$ and ☆ (e) the electric field $\vec{E}$, using the current i and resistivity ρ. *Hint: the radius as a function of x is:* $r(x) = a - \frac{a-b}{L}x$, *if you are interested in being really complete..*