Kuwait University **Physics Department**

Physics 102

Second Midterm Exam
Summer Semester (2008-2009)

August 5, 2009 (6.00- 8:00 p.m.)

Name: ………………………… **Student No: ………………..**

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(Fundamental constants)

$k = \frac{1}{4\pi\varepsilon_o} = 9.0\times10^{9}\ N.m^2/C^2$	(Coulomb constant)
$\varepsilon_o = 8.85 \times 10^{-12}\ C^2/(N\cdot m^2)$	(Permittivity of free space)
$\mu_0 = 4\pi \times 10^{-7}$ T .m/A	(Premeability of free space)
$\lvert e \rvert = 1.60 \times 10^{-19}$ C	(Elementary unit of charge)
$N_A = 6.02 \times 10^{23}$	(Avogadro's number)
$g = 9.8\ m/s^2$	(Acceleration due to gravity)
$m_e = 9.11 \times 10^{-31}$ kg	(Electron mass)
$m_p = 1.67 \times 10^{-27}$ kg	(Proton mass)

Prefixes of units

$m = 10^{-3}$	$\mu = 10^{-6}$	$n = 10^{-9}$	$p = 10^{-12}$
$k = 10^{3}$	$M = 10^{6}$	$G = 10^{9}$	$T = 10^{12}$

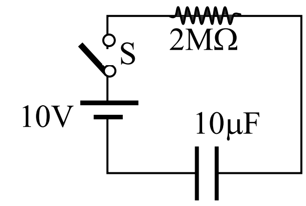
For use by Instructors only

Problem	1	2	3	4	5	6	7	8	Total
Marks									

Question	1	2	3	4	5	6	7	8	Total
Marks									

Part I: Solve the following problems

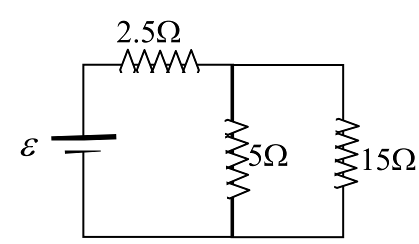
1. In the circuit shown, the capacitor is initially uncharged. The switch S is closed at time t=0. Find the current in the circuit when the charge on the capacitor is 20 μC. **(2 pts)**



$$\varepsilon = RI + \frac{q}{c}$$

$$I = \frac{\varepsilon - q/c}{R} = 4\mu A$$

2. In the circuit shown ε =15 V. Find the current in the 15 Ω resistor. **(3 pts)**



$$R_{eq} = 2.5\Omega + 3.75\Omega = 6.25\Omega$$

$$I = \frac{\varepsilon}{R_{eq}} = 2.4\ A$$

$$\text{in } 15\Omega:\ I = \frac{2.4\,A \times 3.75\,\Omega}{15\Omega} = 0.6\,A$$

3. A parallel-plate capacitor with plate area 0.2 m^2 and plate separation 1 mm is charged by connecting to a 10 V battery, and then the battery is disconnected. If we double the plate separation and insert a dielectric (K = 3) into the capacitor completely filling the gap between the plates, what is the final potential difference between the capacitor plates? **(4 pts)**

$$C_o = \varepsilon_o \frac{A}{d} = 1.77 \text{ nF}$$

$$Q_o = C_o V_o = 17.7 \text{ nC}$$

$$C = K \frac{\varepsilon_o A}{2d} = 2.66 \text{ nF}$$

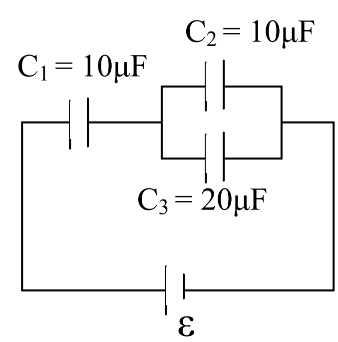
$$V = \frac{Q_o}{C} = 6.67 \text{ V}$$

4. In the capacitor network shown below the magnitude of plate charge on C_2 is 10 μC. Calculate the emf of the battery ($\mathcal{E}$). **(3 pts)**

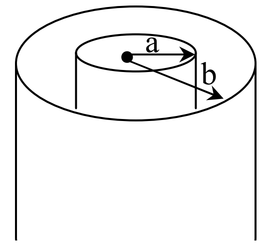
$$Q_3 = C_3 V_3 = C_3 \frac{Q_2}{C_2} = 20 \mu C$$

$$Q_1 = Q_2 + Q_3 = 30 \mu C$$

$$\varepsilon = \frac{Q_1}{C_1} + V_2 = 4 \text{ V}$$



5. Two long conducting cylinders with radii a = 4 cm and b = 6 cm form a capacitor. If the linear charge density on the inner cylinder is +2 μC/m, find the energy density at a distance of *5* cm from the common axis of the cylinders. **(3 pts)**



Between the two cylinders:

$$E = \frac{\lambda}{2\pi\varepsilon_o r}$$

$$E = 7.19\times10^5 \text{ N/C}$$

$$u = \frac{1}{2}\varepsilon_o E^2 = 2.30 \ {}^{j}\!/_{m^3}$$

6. An electron moving in +y direction at a speed of 3×10^5 m/s enters a uniform magnetic field that is in +x direction. Upon entrance, this electron feels a magnetic force of 7.2×10^{-13} N. Find the magnitude and direction of the magnetic force on another electron that is moving in +z direction at 6×10^5 m/s when entering the magnetic field. **(3 pts)**

$$\vec{B} = \frac{F_1}{e v_1}\hat{i} = (15\,T)\,\hat{i}$$

$$\vec{F}_2 = -e v_2\, \hat{k}\times B\hat{i}$$

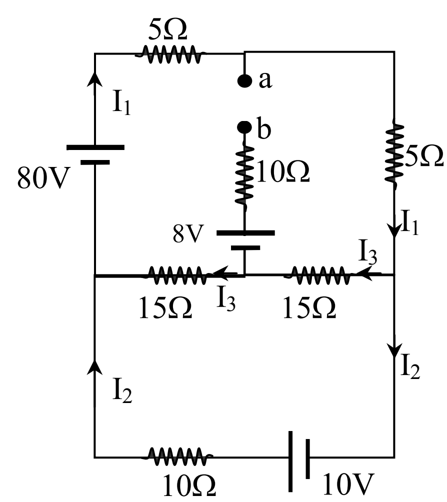
$$= -\left(1.44\times10^{-12}\ N\right)\hat{j}$$

7. Calculate the drift velocity of the electrons in a gold wire of 10 mm diameter which carries a current of 10 A. (The density of free electrons in gold is $5.9\times10^{28}\ m^{-3}$) **(2 pts)**

$$A=\pi\frac{d^2}{4}=7.85\times10^{-5}\ m^2$$

$$v_d=\frac{I}{enA}=1.35\times10^{-5}\ m/s$$

8. In the circuit shown, find the potential difference V_{ab} between the points a and b. **(5 pts)**



$$80V-10I_1-30I_3=0$$

$$10V-10I_2+30I_3=0$$

$$I_2=I_1-I_3$$

$$\Rightarrow I_1=5A,\ \ I_3=1A$$

$$V_{ab}=5I_1+15I_3-8V=32\ V$$

Part II: Conceptual questions. Tick the best answer. (one point for each question)

1. What is the unit of resistivity?

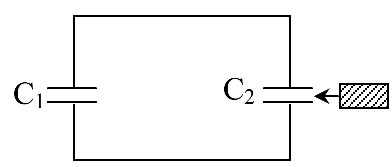
   a) Ωm^{-1} b) $m\Omega$ c) $A\Omega$ d) $m^{-1}\Omega^{-1}$

2. How does the resistance of a piece of conducting wire change if both its length and diameter are doubled?

   a. It becomes 2 times as much.
   b. It becomes 4 times as much.
   c. It becomes ½ as much.
   d. It becomes ¼ as much.

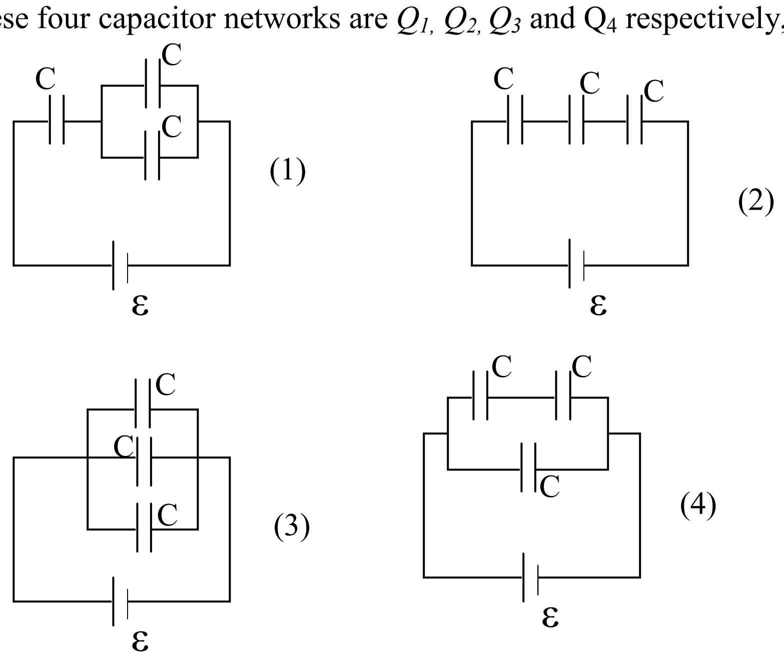
3. The two capacitors in the following diagram are charged. If we insert a dielectric slab between the plates of C_2 filling its volume, the charge on C_2

   a) will increase.
   b) will decrease.
   c) will remain constant.
   d) may increase or decrease.



4. If the total electric charges on these four capacitor networks are Q_1, Q_2, Q_3 and Q_4 respectively, which statement is correct?

   a) $Q_1 < Q_2 < Q_3 < Q_4$
   b) $Q_4 < Q_3 < Q_2 < Q_1$
   c) $Q_2 < Q_1 < Q_4 < Q_3$
   d) $Q_3 < Q_1 < Q_4 < Q_2$



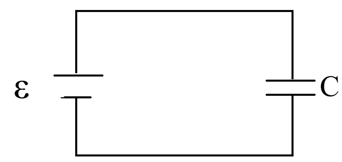
5. The emf of the battery in this diagram is increased to 2ε. As a result, the energy density in the space between the plates of the capacitor

a) increases by a factor of *2*.

(b) increases by a factor of *4*.

c) decreases by a factor of *2*.

d) decreases by a factor of *4*.



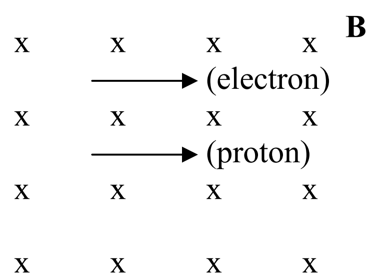
6. A proton and an electron that are moving at the same velocity (*v*) enter a region of uniform magnetic field. If we want the two particles to go on a straight line,

(a) we have to apply an electric field downward perpendicular to *v*.

b) we have to apply an electric field upward perpendicular to *v*.

c) the electric field should be upward for proton and downward for electron.

d) the electric field should be downward for proton and upward for electron.



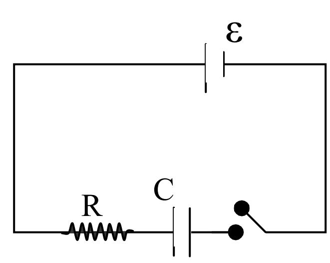
7. In the circuit, the capacitor is uncharged. As soon as the switch is closed,

a) the current in the circuit is zero.

b) the voltage across the capacitor is ε.

c) the voltage across the resistor is zero.

(d) the voltage across the capacitor is zero.



8. The emf of a battery is equal to:

a) the chemical energy stored in the battery.

b) the maximum current supplied by the battery.

c) the amount of charge the battery can pump.

(d) the terminal voltage of the battery when no current flows.