Kuwait University **Physics Department**

Physics 102

Second Midterm Examination

Fall Semester (2011 - 2012)

December 14, 2011

Time: 12:30 – 1:45 PM

Name……..Student No……

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_____ Marafi, Pichler, Rakhshani, Razee and Sharma_____

(Fundamental constants)

$k = \frac{1}{4\pi\varepsilon_o} = 9.0\times10^9\ Nm^2/C^2$	(Coulomb constant)
$\varepsilon_o = 8.85 \times 10^{-12}\ C^2/(Nm^2)$	(Permittivity of free space)
$\mu_0 = 4\pi \times 10^{-7}$ Tm/A	(Permeability 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}	μ = 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

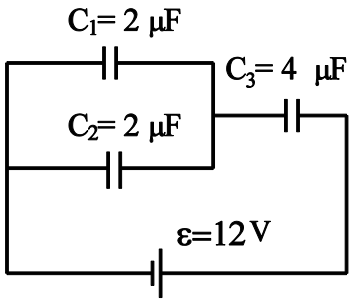
Prob.	1	2	3	4	5	6	Total
Marks							

Ques.	1	2	3	4	5	6	Total
Marks							

Problems ***Please show all working.***

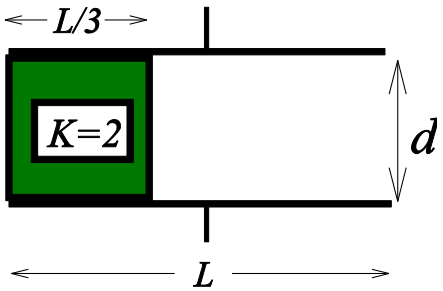
1. Three capacitors and a battery are connected in a circuit as shown in the figure. Find the charge on capacitor C_2. **[4 points]**

$$C_{12} = C_1 + C_2 = 4\mu F;$$
$$C_{123} = \frac{C_{12}C_3}{C_{12} + C_3} = 2\mu F$$
$$Q_{123} = C_{123}\varepsilon = 24\mu C = Q_{12}$$
$$Q_2 = Q_{12}/2 = 12\mu C$$



2. One third of the space between the plates of a parallel-plate capacitor is filled with a dielectric of dielectric constant K=2. The capacitance of this capacitor is 120 μF. Calculate the capacitance of the parallel-plate capacitor in the absence of the dielectric material. **[4 points]**

$$(C_0 \text{ is the capacitance without } K)$$
$$C_L = \frac{C_0}{3}K$$
$$C_R = \frac{2C_0}{3}$$
$$C_{eq} = C_L + C_R = C_0\frac{4}{3} = 120\ \mu F \Rightarrow$$
$$\Rightarrow C_0 = 120\ \mu F\frac{3}{4} = 90\mu F$$

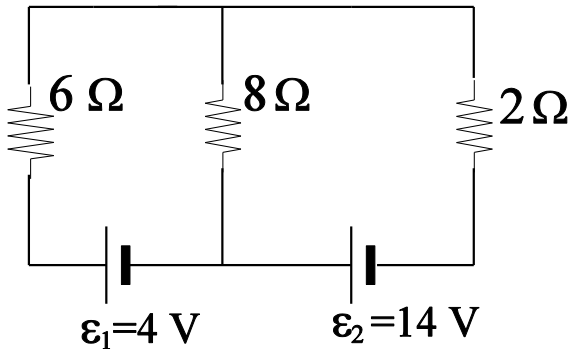


3. A high voltage line of diameter 2 cm and length 20 km carries a steady current of 10 A. If the conductor has a free charge density of 8×10^{28} m^{-3}, find how long it takes one electron to travel the full length of the cable. **[3 points]**

$$J = nev_d \Rightarrow\Rightarrow v_d = \frac{J}{ne} = \frac{I}{Ane} =$$
$$\frac{10A}{\pi(0.01m)^2 8\times10^{28}m^{-3}1.6\times10^{-19}C} = 2.5\times10^{-6}m/s$$
$$t = \frac{L}{v_d} = \frac{2\times10^4 m}{2.5\times10^{-6}m/s} = 8\times10^9 s$$

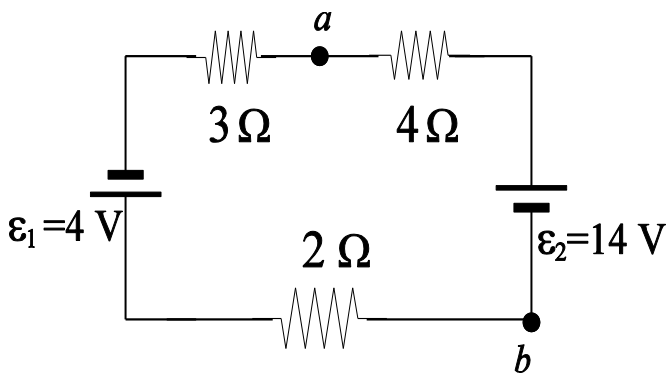
4. In the circuit shown, find the power supplied to the circuit by the battery of emf ε_1. **[5 points]**

$$\text{junction rule}: \quad I_L + I_M = I_R$$
$$\text{left loop}: \quad 4V - I_L 6\Omega + I_M 8\Omega = 0$$
$$\text{outer loop}: \quad 14V + 4V - I_L 6\Omega - I_R 2\Omega = 0$$
$$\text{from which}: I_L = 2A$$
$$P = IV = 8W$$

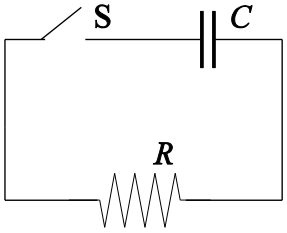


5. In the circuit shown, find the potential difference V_a-V_b. **[4 points]**

$$4V - I2\Omega + 14V - I4\Omega - I3\Omega = 0$$
$$I = 2A$$
$$V_a + 2A \cdot 4\Omega - 14V = V_b$$
$$V_a - V_b = 6V$$



6. In the circuit shown, the switch S is closed at *t=0* and the capacitor *C* of initial charge Q_0 discharges via the resistor *R*.



(a) Derive an expression for the current in the circuit as a function of time. **[2 points]**

$$I(t) = -\frac{dQ}{dt} = \frac{Q_0}{RC} e^{-\frac{t}{RC}}$$

(b) Write an expression for the power dissipated in the resistor *R* as a function of time. **[1 point]**

$$P = V(t)I(t) = \frac{Q_0}{C} e^{-\frac{t}{RC}} \frac{Q_0}{RC} e^{-\frac{t}{RC}} = \frac{Q_0^2}{RC^2} e^{-\frac{2t}{RC}}$$

(c) Write an integral for the energy dissipated in the resistor *R* between *t=0* and *t = 10RC* times. **[2 points]**

$$E_{diss} = \int_0^{10RC} \frac{Q_0^2}{RC^2} e^{-\frac{2t}{RC}} dt$$

<u>Conceptual questions.</u> Each one point. ***Tick (√) the best answer.***

1. A parallel-plate capacitor is charged and removed from the battery. When the plates are pulled apart, which of the following quantities decrease?

   (a) The electric field between the plates.

   (b) The charge on the plates.

   (c) The capacitance of the capacitor. **(Ans.)**

   (d) The potential difference between the plates.

   (e) The energy density of the electric field.

2. How does the resistance of a wire change if its length is doubled and its diameter is halved?

   a) Decreases by a factor of 2.

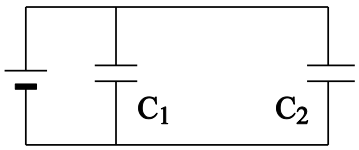
   b) Increases by a factor of 2.

   c) Increases by a factor of 4.

   d) Increases by a factor of 8. **(Ans.)**

   e) Remains the same.

3. Capacitors C_1 and C_2 ($C_1 < C_2$) are connected in parallel with a battery. Which of the following statement is true?



   (a) The potential difference across C_1 is greater than across C_2.

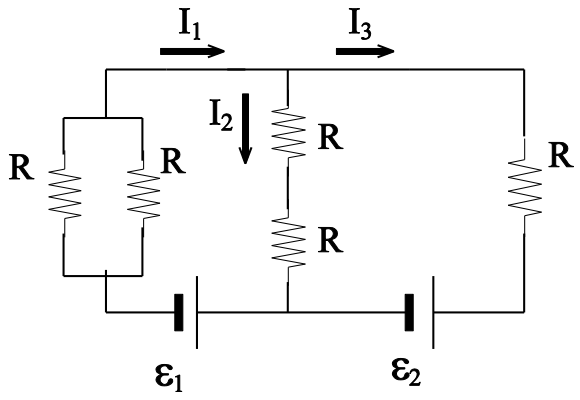
   (b) The potential differences across C_1 and C_2 are equal. **(Ans.)**

   (c) The potential difference across C_2 is greater than across C_1

   (d) The charges stored in C_1 and C_2 are equal.

   (e) The charge stored in C_1 is larger than the charge stored in C_2.

4. Which of the following is a correct Kichhoff junction rule equation for the currents in the circuit?



(a) $I_1+I_2+I_3=0$

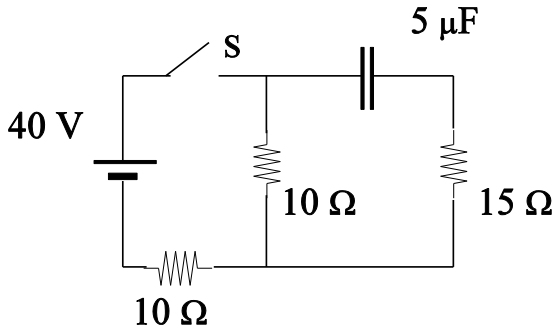
(b) $I_1+I_2=I_3$

(c) $I_1+I_3=I_2$

(d) $I_2+I_3=I_1$ **(Ans.)**

(e) None of the above is correct.

5. Long time after the switch *S* is closed, the current in the 15-Ω resistor is



a) 2.6 A.

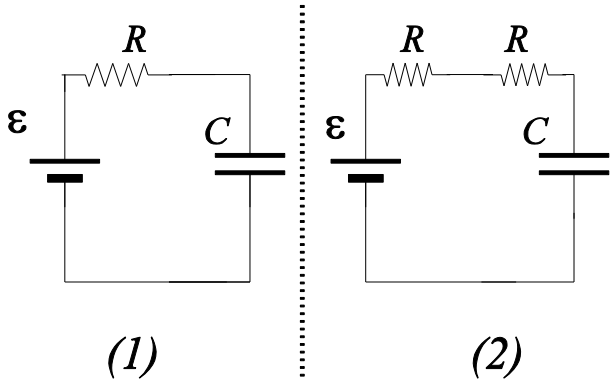
b) 2.5 A.

c) 2.0 A.

d) 1.6 A.

e) 0.0 A. **(Ans.)**

6. In the two separate *R*-*C* circuits the relation between the time constants τ_1 and τ_2 of circuits 1 and 2 is



(a) $\tau_1 = 0.25\ \tau_2$.

(b) $\tau_1 = 0.5\tau_2$. **(Ans.)**

(c) $\tau_1 = \tau_2$.

(d) $\tau_1 = 2\tau_2$.

(e) $\tau_1 = 4\tau_2$.