University of Bahrain | Physics 102 | Second Exam. | Fall 2004

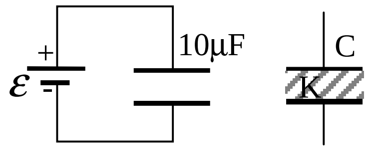
Department of Physics | Tuesday 21/12/2004 | 11:00 –12:00

Name:____ ID no.:______________________

$k = 9\times10^{9}\ Nm^2/C^2$, $e = 1.6\times10^{-19}C$, $m_p = 1.67\times10^{-27}$ Kg,

$\varepsilon_0 = 8.85\times10^{-12}\ C^2/Nm^2$ $m_e = 9.11\times10^{-31}$ Kg, $g = 10\ m/s^2$

Q1: An air filled capacitor of $C_0 = 10\mu F$ is fully charged using a 12 V battery as shown in the figure. The capacitor is then disconnected from the battery and filled with a dielectric material of K= 4. The electric potential (in V) across the capacitor after being filled with the dielectric is:

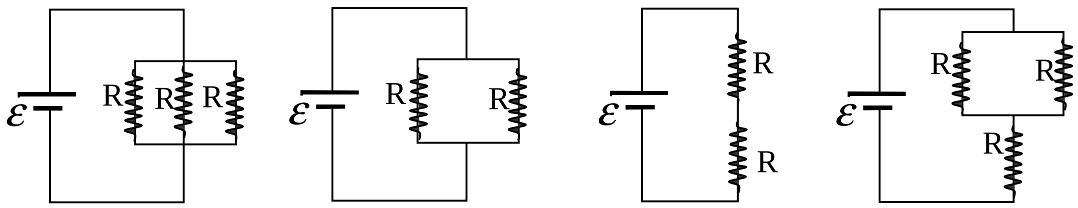


(A) 2 (B) 3 (C) 4 (D) 5 (E) 6

Q2: The density of free electrons in gold is $5.9\times10^{28}\ m^{-3}$. A gold wire, 10mm in diameter and carries a current of 5 A. The drift velocity (in μm/s) of the electrons in the wire is:

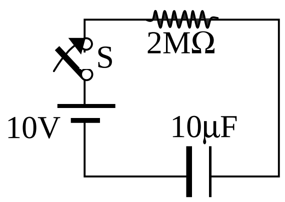
(A) 2.7 (B) 4 (C) 5.4 (D) 6.7 (E) 8.1

Q3: In the circuits shown, all batteries have the same emf ($\mathcal{E}$) and all resistors are equal. In which circuit is the power supplied by the battery greatest?



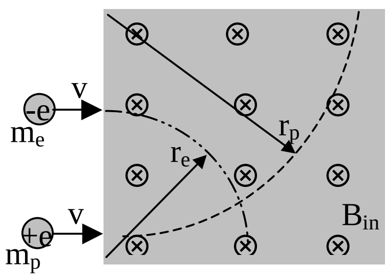
(A) (B) (C) (D)

Q4: In the circuit shown, the capacitor is initially uncharged. The switch S is closed at time t=0. When the charge on the capacitor is 52.76 μC the current (in μA) in the circuit is:



(A) 3.89 (B) 3.03 (C) 2.36 (D) 1.84 (E) 1.43

Q5: A proton and electron have the same speed (v) and enter a region of uniform magnetic field pointing into the plane of the page as shown in the figure. If the radius of the electron's path r_e= 0.5 cm then the radius of the proton's path r_p (in cm) is:
(Note: m_p/m_e=1833)



(A) 183.3 (B) 366.6 (C) 550 (D) 733.2 (E) 916.5

Solutions of the above questions

Q1: $Q_i = Q_f \rightarrow C_o \times 12 = 4C_o \times V \therefore V = 3V$

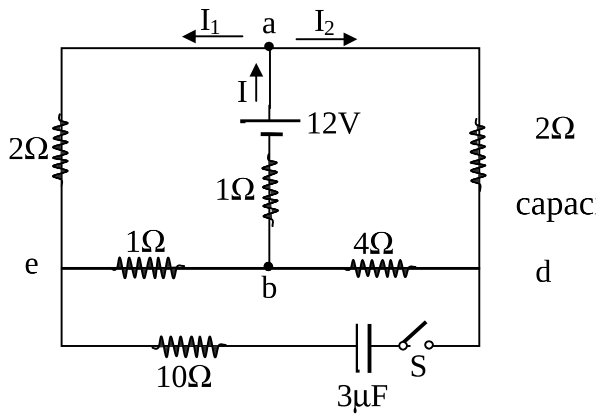
Q2: $I = An_{el}e\upsilon_d, \quad \upsilon_d = 6.7\mu m/s$

Q3: $P_{\text{supplied}} = P_{dissipated} = \varepsilon I = \dfrac{\varepsilon^2}{R_{eq}}$, greatest (P) corresponds to lowest $\mathrm{R_{eq}}$, as in Fig(A)

Q4: $Q = C\varepsilon\left(1-e^{-t/\tau}\right)$ and $I = \dfrac{\varepsilon}{R}e^{-t/\tau}$, then $I = \dfrac{\varepsilon}{R}\left(1-\dfrac{Q}{C\varepsilon}\right) = 2.36\mu A$

Q5:

$$\left.\begin{aligned} r_e &= \frac{m_e\upsilon_e}{eB} \\ r_p &= \frac{m_p\upsilon_p}{eB} \end{aligned}\right\} \frac{r_e}{r_p} = \frac{m_e}{m_p}, r_p = 1833r_e = 916.5cm$$



Problem (1) (30 Marks):

For the circuit shown the switch S is open and the capacitor is uncharged. Find:

(a)- The current I .

$$\left.\begin{array}{l} Left\,loop\,1: 12 = I + 3I_1 \\ Right\,loop\,2: 12 = I + 6I_2 \end{array}\right\} I_1 = 2I_2$$

$$12 = (I_1 + I_2) + 3I_1, \qquad I_2 = \frac{12}{9}A, I_1 = \frac{24}{9}A$$

$$\therefore I = 4A$$

(b) The power supplied by the battery.

$$P_s = \varepsilon I = 48W$$

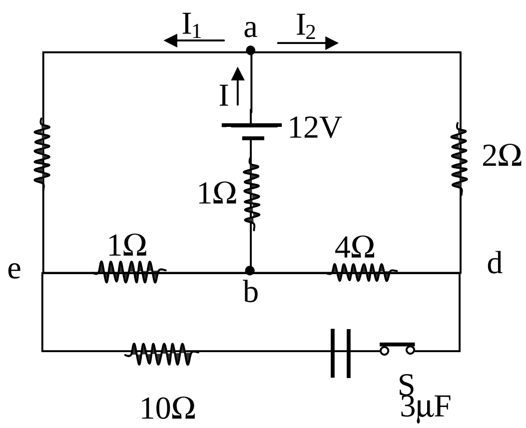
(c)- The magnitude of the potential difference between points a and b (V_{ab}).

$$V_{ab} = \sum_k I_k R_k - \sum_k \varepsilon_k = (-I)\times 1 - (-12) = 8V$$

$$or \qquad V_{ab} = (I_1)(3) = 8V$$

Now the switch S is **closed for a long time**.

(d)- What will be the current in the 10 Ω resistor?



C is fully charged

I_C = Zero

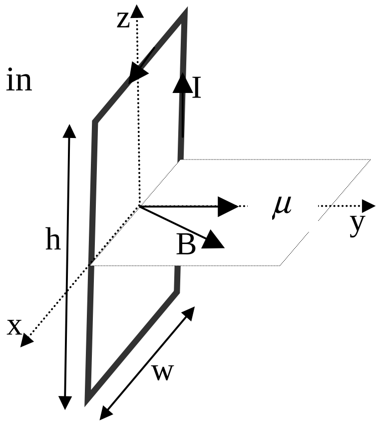
(e)- Find the charge on the capacitor.

$$V_c = V_{de} = (I_2)(4) + (-I_1)(1)$$

$$= 2.667V$$

$$Q = CV_C \simeq 8\mu c$$

Problem (2) (20 Marks):



A rectangular loop of height h = 0.6 m and width w = 0.2 m lies in the x-z plane as shown in the figure. If the loop carries a current of I = 20 A and is placed in a uniform magnetic field. $\vec{B} = 0.3\hat{i} + 0.4\hat{j}$ (T) (i.e. B lies in the x-y plane) then find:

(a)- The **magnitude and direction** of the magnetic dipole moment (μ) of the loop.

$$\left|\vec{\mu}\right| = IA = 2.4 A.m^2$$

$$\vec{\mu} = 2.4\,\vec{j}\left(A.m^2\right)$$

(b)- The initial **magnitude and direction** of the torque on the loop.

$$\vec{\tau} = \vec{\mu} \wedge \vec{B} = 2.4\,\vec{j} \wedge \left[0.3\,\vec{i} + 0.4\,\vec{j}\right]$$

$$\vec{\tau} = 0.72\left(-\vec{k}\right) N.m$$

$$magnitude = 0.72\, N.m$$

$$direction = -\vec{k}$$