1.

(a) Capacitor : A capacitor is a device for storing electric charge. The forms of practical capacitors very widely, but all contain at least two conductors separated by a non-conductor. It consists of two conductors carrying charges of equal magnitude and opposite sign.

Inductor : An inductor is a passive electrical component that can store energy in magnetic field created by the electric current passing through it. Typically an inductor is a conducting wire shaped as a coil; the loops help to create a strong magnetic field inside the coil due to Ampere's Law. Due to the time-varying magnetic field inside the coil, a voltage is induced, according to Faraday's law of electromagnetic induction, which by Lenz's Law opposes the change in current the created it.

(b) Maxwell's Equations

① $\oint_S \vec{E} \cdot d\vec{A} = \dfrac{q_{enc}}{\epsilon_0}$ 电場的高斯定律 电荷會產生一個电場,电場會有通量,而穿過任何封閉表面的电通量,和被包圍在該封閉表面内的總电荷量成正比

② $\oint_S \vec{B} \cdot d\vec{A} = 0$ 磁場的高斯定律 穿過任何封閉表面的總磁通量,等於零

→ 自然界没有單獨存在的磁極 (没有磁單極)

③ $\oint_C \vec{E} \cdot d\vec{\ell} = -\dfrac{d\Phi_B}{dt}$ 法拉第定律 穿過一個表面的磁通量变化,會在該表面的任何邊界路徑感應出一個电动勢,而一個变化的磁場會感應出一個環狀的电場

④ $\oint_C \vec{B} \cdot d\vec{\ell} = \mu_0 I_{enc} + \epsilon_0 \mu_0 \dfrac{d\Phi_E}{dt}$ 安培-馬克士威定律 一個电流、或者是一个变化的电通量,穿過一个表面時,會產生一個循環的磁場,該磁場會以該表面的邊界為路徑而環繞

2.

$\because P = IV = \frac{W}{t}$

$\therefore \underset{H}{\overset{}{W}} = IVt = 5_A \times 120_V \times (5\times 60)_{sec}$

or H

$= 18000$ j·sec

$= 43020$ cal·sec

$\uparrow$

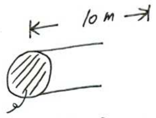
1 joule = 0.239 cal

Ans: 約 43020 calories

or

43000

3.




Area = $3\ mm^2$

$= 3\times10^{-6}\ m^2$

$$R = \rho \frac{l}{A}$$

$$= 1.72\times10^{-8}\ \Omega\cdot m \ \frac{10\ m}{3\times10^{-6}\ m^2}$$

$$= 0.057\ (\Omega)$$

#

4.

(a) The circular motion's centrifugal force is provided by the electric force between the electron and nucleus.

$$F = k_e \frac{ze \cdot e}{r^2} = m_e \frac{v^2}{r}$$

$$L = |\vec{r} \times \vec{p}| = |\vec{r} \times m_e \vec{v}| \underset{\vec{r} \perp \vec{v}}{=} m_e v r \quad \# \quad \underset{\text{若利用上式把}v\text{給取代}}{=} \sqrt{m_e r k_e z e^2}$$

(b) The total classical energy $E = E_k + E_p$

$$\begin{cases} E_k = \text{the kinetic energy of the electron with velocity} \\ E_p = \text{the electric potential energy} \end{cases}$$

$$\therefore \ E = \frac{1}{2} m_e v^2 - k_e \frac{ze^2}{r} = \frac{1}{2} \frac{k_e z e^2}{r} - \frac{k_e z e^2}{r} = -\frac{k_e z e^2}{2r} \quad \# \quad \underset{k_e = \frac{1}{4\pi\epsilon_0}}{=} -\frac{ze^2}{4\pi\epsilon_0 (2r)}$$

(c) $L = m_e v r = \sqrt{m_e r k_e z e^2} \Rightarrow L^2 = m_e r k_e z e^2$

$$E = -\frac{k_e z e^2}{2r} \underset{\text{為了符合題意：“in terms of charge and angular momentum” 分子分母同乘 } m_e k_e z e^2}{=} -\frac{m_e k_e^2 z^2 e^4}{2 m_e r k_e z e^2} = -\frac{m_e k_e^2 z^2 e^4}{2L^2} \quad \# \quad \underset{k_e = \frac{1}{4\pi\epsilon_0}}{=} -\left(\frac{m_e e^4}{32\pi^2 \epsilon_0^2}\right) \frac{z^2}{L^2}$$

(d) If $L = n\hbar \Rightarrow E = -\frac{m_e k_e^2 z^2 e^4}{2L^2} = -\frac{m_e k_e^2 z^2 e^4}{2 n^2 \hbar^2} \quad \# \quad \underset{k_e = \frac{1}{4\pi\epsilon_0}}{=} -\left(\frac{m_e e^4}{32\pi^2 \epsilon_0^2}\right) \frac{z^2}{n^2 \hbar^2}$

(e) From (c), $L^2 = m_e r k_e z e^2 = n^2 \hbar^2$

$$\Rightarrow r = \frac{n^2 \hbar^2}{m_e k_e z e^2} = \left(\frac{\hbar^2}{m_e k_e e^2}\right) \frac{n^2}{z} = \frac{a_0}{z} n^2$$

$$\therefore \ a_0 = \frac{\hbar^2}{m_e k_e e^2} \cong 5.31 \times 10^{-11}\, m \cong 0.53\,(\text{Å}) \quad \#$$

5.

When the current through $R_5$ is zero, then $V_{BC} = 0$

$\because$ $I_{R_1} = I_{R_3} = I$ , $I_{R_2} = I_{R_4} = I'$

$\therefore$ $\Delta V_{AB} = IR_1$ , $\Delta V_{BD} = IR_3$

$\Delta V_{AC} = I'R_2$ , $\Delta V_{CD} = I'R_4$

But $\Delta V_{AB} = \Delta V_{AC}$ , $\Delta V_{BD} = \Delta V_{CD}$

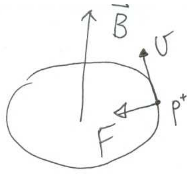
i.e., $IR_1 = I'R_2$ , $IR_3 = I'R_4$

利用上述關係式，利用 $R$ 來表示 $I$ 與 $I'$

$$\Rightarrow \frac{R_2}{R_1} = \frac{R_4}{R_3} \quad \#$$

(無論順序怎麼移動，只要維持"$R_1R_4 = R_2R_3$"即可)

6.




$$F = m\frac{v^2}{R} \Rightarrow |q\vec{v}\times\vec{B}| = evB = m\frac{v^2}{R}$$

$$\therefore R = \frac{mv}{eB}$$

$$1\text{ MeV} = 10^6\text{ eV} \times \frac{1.6\times10^{-19}\text{ J}}{1\text{ eV}} = 1.6\times10^{-13}\text{ J}$$

$$= \frac{m_0c^2}{\sqrt{1-\beta^2}} - m_0c^2$$

$$= \left[\frac{1}{\sqrt{1-\beta^2}} - 1\right]m_0c^2$$

$$m_0c^2 = 1.67\times10^{-27}\text{ kg}\times(3\times10^8\text{ m/s})^2 \cong 1.5\times10^{-10}\text{ J}$$

$\because$ $1.6\times10^{-13}\text{ J} \ll 1.5\times10^{-10}\text{ J}$ (即 $KE \ll m_0c^2$)

$\therefore$ We have a non-relativistic motion

i.e., $\beta = \frac{v}{c} \ll 1$

$$\Rightarrow \frac{1}{\sqrt{1-\beta^2}} = (1-\beta^2)^{-\frac{1}{2}} \underset{\beta\ll1}{\simeq} 1+\frac{1}{2}\beta^2$$

$$故 \left[\frac{1}{\sqrt{1-\beta^2}} - 1\right]m_0c^2 = \frac{1}{2}\beta^2 m_0c^2 = 1.6\times10^{-13}\text{ J}$$

$$\Rightarrow \beta^2 = \left(\frac{v}{c}\right)^2 = \frac{3.2\times10^{-13}\text{ J}}{1.5\times10^{-10}\text{ J}}$$

$$\Rightarrow v = \sqrt{\frac{3.2\times10^{-13}\times(3\times10^8)^2}{1.5\times10^{-10}}} \cong 1.38\times10^7\text{ m/s}$$

$$\therefore R = \frac{mv}{eB} = \frac{(1.67\times10^{-27})\text{ kg}\times(1.38\times10^7)\text{ m/s}}{(1.6\times10^{-19})\text{ C}\times1\text{ T}} = 1.44\times10^{-1}\text{ m}$$

$$= 14.4\text{ cm}$$ #