PHY 2049

Test II – 31 Oct 2016

— Solutions —

V.I

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(1) (a) Energy conservation → $K_B = U_A \Rightarrow \frac{1}{2} m_p v^2 = eV$

4/ $v = 3.10 \times 10^5$ m/s → $\boxed{V = m_p v^2/2e = 501\ V}$

(b) Cyclotron frequency $\omega_c = eB/m$ with $B = 0.400T$

6/ $\rightarrow \omega_c = 3.837 \times 10^7$ rad/s $\rightarrow \omega_c = v/r \Rightarrow r = v/\omega$

$\Rightarrow d = 2r = 2v/\omega_c = 1.62 \times 10^{-2}$ m → $\boxed{d = 1.62\ cm}$

(c) $q_\alpha = 2e \Rightarrow K_\alpha = 2K_p$ at point B if V the same.

5/ Now $K_\alpha = \frac{1}{2} m_\alpha v_\alpha^2 = \frac{1}{2}(4m_p) v_\alpha^2 \Rightarrow 2(\frac{1}{2} m_p v_\alpha^2) = K_\alpha/2 = K_p$

$\Rightarrow 2 v_\alpha^2 = 2K_p/m_p = v_p^2 \Rightarrow \boxed{v_\alpha = v_p/\sqrt{2} = 2.19 \times 10^5\ m/s}$

(d) $q_\alpha/m_\alpha = \frac{1}{2}(q_p/m_p) \Rightarrow \omega_c(\alpha) = \frac{1}{2}\omega_c(p)$

5/ $\Rightarrow d_\alpha = 2v_\alpha/\omega_c(\alpha) = 2(v_p/\sqrt{2})/[\frac{1}{2}\omega_c(p)] = \sqrt{2} d_p \Rightarrow \boxed{d_\alpha = 2.29\ cm}$

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(2) (a) $r = 0.200$ cm $\Rightarrow A = \pi r^2 = 1.257 \times 10^{-5}\ m^2$

5/ $\rho_r = 3.00 \times 10^{-3}\ \Omega$-m, $l = 1.50$ cm → $\boxed{R = \rho_r l/A = 3.58\ \Omega}$

(b) Method 1: $I = 5.00$ A → $V = IR = 17.90$ V

5/ $\rightarrow \boxed{E = V/l = 1.19 \times 10^3\ V/m}$

Method 2: $j = I/A = 3.979 \times 10^5\ A/m^2 \rightarrow E = \rho_r j = 1.19 \times 10^3$ V/m

4/ (c) Power → $P = I^2 R = 89.52$ W → $\Delta t = 3.5$ sec → $\boxed{\Delta U = P\Delta t = 313\ J}$

6/ (d) Increased current → decreased resistance

→ parallel connection

$I' = 2.5\ I \Rightarrow R_{equ} = R/2.5$

$R_{equ} = RR_2/(R+R_2)$ for parallel connection

$\Rightarrow R(R+R_2) = 2.5\ RR_2 \Rightarrow 1.5\ R_2 = R \Rightarrow \boxed{R_2 = \frac{2}{3}R = 2.34\ \Omega}$

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(3) (a) 6/ $R_1 = 2.00\,\Omega$, $R_2 = 1.50\,\Omega$, $R_3 = 2.50\,\Omega$

R_2 and R_3 in parallel $\Rightarrow R_{23} = R_2R_3/(R_2+R_3) = 0.9375\,\Omega$

R_1 and R_{23} in series $\rightarrow$ $\boxed{R_{equ} = R_1 + R_{23} = 2.94\,\Omega}$

(b) 4/ $\mathcal{E} = 15.0\text{ V} \rightarrow I_1 = \mathcal{E}/R_{equ} = 5.106\text{ A} \rightarrow \boxed{V_1 = I_1R_1 = 10.2\text{ V}}$

(c) 5/ Potential drop across 2 and 3 $\rightarrow V_{23} = \mathcal{E} - V_1 = 4.787\text{ V}$

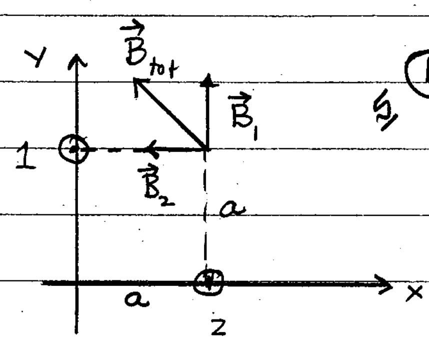
Alternatively, $V_{23} = I_1R_{23} = 4.787\text{ V}$

$\rightarrow \boxed{I_2 = V_{23}/R_2 = 3.19\text{ A}}$ $\boxed{I_3 = V_{23}/R_3 = 1.91}$ or $I_3 = I_1 - I_2$

(d) 5/ $P_{R_1} = I_1^2R_1 = 52.2\text{ W}$ $P_{R_2} = I_2^2R_2 = 15.3\text{ W}$ $P_{R_3} = I_3^2R_3 = 9.17\text{ W}$

$P_{batt} = \mathcal{E}I_1 = 76.6$ $\rightarrow$ Note that $P_{R_1} + P_{R_2} + P_{R_3} = P_{batt}$

(4) (a) 4/



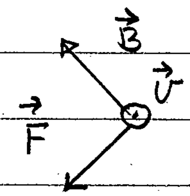
(b) 5/ From figure, $B_{tot} = \sqrt{2}\,B_1$

$I = 15.0\text{ A}$, $a = 5.0 \times 10^{-2}\text{ m}$

$\rightarrow B_1 = \mu_0 I/2\pi a = 6.00 \times 10^{-5}\text{ T}$

$\rightarrow \boxed{B_{tot} = 8.49 \times 10^{-5}\text{ T}}$

(c) 5/

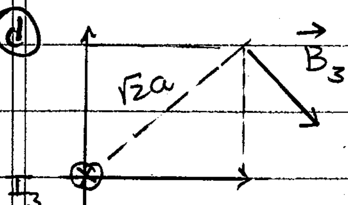


direction from right hand rule $\rightarrow$ toward origin

$q = 2.00 \times 10^{-6}\text{ C}$ $v = 3.0 \times 10^4\text{ m/s}$

$\rightarrow \boxed{F = qvB = 5.09 \times 10^{-6}\text{ N}}$

(d) 6/



$\vec{B}_3$ must oppose $\vec{B}_1 + \vec{B}_2$

$\rightarrow$ I_3 in $-z$ direction (into page)

Now $B_3 = \mu_0 I_3/2\pi r$

with $B_3 = 8.49 \times 10^{-5}\text{ T}$ and $r = \sqrt{2}a = 7.071 \times 10^{-2}\text{ m}$

$\rightarrow \boxed{I_3 = 2\pi r B_3/\mu_0 = 30.0\text{ A}}$