(A)

【1】 $E_1 \dfrac{R_1}{R_2}$	【2】 $\dfrac{2\kappa_3(\kappa_1+\kappa_2)}{2\kappa_3+\kappa_1+\kappa_2}C_0$	【3】 50/995 = 0.0503	【4】 9990
【5】 590	【6】 $\dfrac{V}{R_2+R_3}$	【7】 $\dfrac{V}{R_1}$	【8】 $C(R_1+R_2+R_3)$
【9】 $-2z\exp[-(x^2+z^2)]+\dfrac{1}{yz^2}$	【10】 (C)(A)(B)	【11】 $5\sigma/(2\varepsilon_0), \rightarrow$	【12】 $\sigma/(2\varepsilon_0), \rightarrow$
【13】 16	【14】 $2aQE_0(\mathbf{i}-\mathbf{j})$	【15】 −2m	

(B)

【1】 $\dfrac{2\kappa_3(\kappa_1+\kappa_2)}{2\kappa_3+\kappa_1+\kappa_2}C_0$	【2】 $\dfrac{V}{R_2+R_3}$	【3】 $\dfrac{V}{R_1}$	【4】 $C(R_1+R_2+R_3)$
【5】 $E_1 \dfrac{R_1}{R_2}$	【6】 (C)(A)(B)	【7】 $-2z\exp[-(x^2+z^2)]+\dfrac{1}{yz^2}$	【8】 50/995 = 0.0503
【9】 9990	【10】 590	【11】 $5\sigma/(2\varepsilon_0), \rightarrow$	【12】 $\sigma/(2\varepsilon_0), \rightarrow$
【13】 −2m	【14】 16	【15】 $2aQE_0(\mathbf{i}-\mathbf{j})$	

Part II

(1)

Using Gauss's Law

While r < R

$$2\pi r L E = \frac{1}{\epsilon_0}\int_0^r A r L\, 2\pi r\, dr = \frac{2 A L \pi}{\epsilon_0}\int_0^r r^2\, dr = \frac{2 A L \pi}{3\epsilon_0} r^3$$

$$E = \frac{A}{3\epsilon_0} r^2 \text{ ……… (a)}$$

While r > R

$$2\pi r L E = \frac{1}{\epsilon_0}\int_0^R A r L\, 2\pi r\, dr =$$

$$\frac{2 A L \pi}{\epsilon_0}\int_0^r r^2\, dr = \frac{2 A L \pi}{3\epsilon_0} R^3$$

$$E = \frac{A}{3\epsilon_0}\frac{R^3}{r} \text{ ……… (b)}$$

(2)

$$\rho = \frac{Q}{(\frac{4}{3}\pi R^3)}$$

For r < R

$$4\pi r^2 E = \frac{1}{\epsilon_0}\int_0^r \rho\, 4\pi r^2\, dr = \frac{1}{\epsilon_0}\frac{r^3}{R^3} Q$$

$$E = \frac{1}{4\pi\epsilon_0}\frac{rQ}{R^3}\left(\text{or } k\frac{rQ}{R^3}\right) \ldots\ldots (a)$$

For r > R

$$E = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}$$

$$V(r) = -\int_\infty^r E(r)\,dr = -\left(\int_\infty^R E(r)\,dr + \int_R^r E(r)\,dr\right)$$

$$= -\left(\int_\infty^R \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}\,dr + \int_R^r \frac{1}{4\pi\epsilon_0}\frac{rQ}{R^3}\,dr\right)$$

$$= -\frac{Q}{4\pi\epsilon_0}\left(\frac{-1}{R} + \frac{r^2 - R^2}{2R^3}\right)$$

$$= \frac{Q}{4\pi\epsilon_0}\frac{3R^2 - r^2}{2R^3}\left(\text{or } \frac{kQ(3R^2 - r^2)}{2R^3}\right) \ldots\ldots (b)$$

Consider the total energy in the entire space by $u = \epsilon_0 E^2/2$

$$U = \int_0^\infty \frac{1}{2}\epsilon_0 E(r)^2\, 4\pi r^2\, dr$$

$$= 2\pi\left(\int_r^R \left(k\frac{rQ}{R^3}\right)^2 r^2\,dr + \int_R^\infty \left(k\frac{Q}{r^2}\right)^2 r^2\,dr\right)$$

$$= 2\pi k^2 \epsilon_0 Q^2\left(\int_0^R \frac{r^4}{R^6}\,dr + \int_R^\infty \frac{1}{r^2}\,dr\right)$$

$$= \frac{kQ^2}{2}\left(\frac{R^5}{5R^6} + \frac{1}{R}\right)$$

$$= \frac{3kQ^2}{5R} \ldots\ldots (c)$$

(3)

By Gauss' s Law

$$E\,L\,2\pi r = \frac{Q}{\epsilon_0}$$

$$E = \frac{1}{2\pi\epsilon_0}\,\frac{Q}{Lr}$$

$$V_b - V_a = -\int_a^b \frac{1}{2\pi\epsilon_0}\,\frac{Q}{Lr}\,dr$$

$$= -\frac{1}{2\pi\epsilon_0}\,\frac{Q}{L}\ln\left(\frac{b}{a}\right)$$

$$C = \frac{Q}{V} = \frac{2\pi\epsilon_0 L}{\ln(b/a)}\left(\text{or } \frac{L}{2k\ln(b/a)}\right)\ldots\ldots(a)$$

$$C' = \frac{C}{2}\,1.5 + \frac{C}{2}\,2$$

$$= 1.75\,C = \frac{3.5\,\pi\epsilon_0 L}{\ln(b/a)} = \frac{0.875\,L}{k\ln(b/a)}\ \ldots\ldots..(b)$$

(4)

(a) S2 open, no current through capacitor, both currents through 3Ω and 5Ω are 4 A. $V_a = 24 - 4\times5 = 4$ (V), $V_b = 24 - 4\times3 = 12$ (V). Therefore, $V_a - V_b = -8$ (V).

(b) S2 close and steady state, no current through capacitor, Therefore, $V_a - V_b = -8$ (V).

(c) $R_a = 4\ \Omega$, $R_b = 8\ \Omega$, thus $R^{-1} = (1/4) + (1/8)$, $R = 8/3\ \Omega$. Thus $RC = 10 \times 8/3\ \mu s = 26.7\ \mu s$.