CL-611 Quiz - 2 Solution

(1) porosity, $\varepsilon = \dfrac{V_{voids}}{V_{Total}}$

$$= 1 - \frac{V_{solid}}{V_{Total}}$$

$V_{Total} = \pi \times (\text{radius})^2 \times$ thickness of electrode

radius = 7 mm

thickness = 142 − 12 = 130 μ

$$V_{Total} = \pi \times 0.7 \times 0.7 \times (130 \times 10^{-4})\ cm^3$$

$$V_{Total} = 0.02\ cm^3$$

$$V_{solid} = \frac{m_{solid}}{\rho}, \quad m_{solid} = 32 - 13 = 19\ mg$$

$$= \frac{m_{Graphite}}{\rho_{graphite}} + \frac{m_{PVDF}}{\rho_{PVDF}}$$

$$= \frac{0.95 \times 19 \times 10^{-3}\ g}{2.26\ g/cc} + \frac{0.05 \times 19 \times 10^{-3}\ g}{1.78\ g/cc}$$

$$= 8.52 \times 10^{-3}\ cm^3$$

$$\therefore \varepsilon = 1 - \frac{0.52 \times 10^{-5}\ cm^3}{0.02\ cm^3}$$

$$= 0.5739$$

$$\boxed{\varepsilon \approx 57\%}$$

→ particle

2)

$$a = \frac{m^2_{BET}}{m^3} \quad \begin{matrix} \rightarrow \text{Actual surface Area} \\ \rightarrow \text{Volume of electrode} \end{matrix}$$

$$= \frac{\text{No. of particles} \times \text{Surface Area of 1 particle}}{\text{vol}^m \text{ of Electrode}}$$

$$= \cancel{\frac{N \times 2\pi r l}{\pi r^2 l}}$$

$$= \frac{N \times 2\pi r l}{A \times d}$$

porosity, $\varepsilon = 1 - \dfrac{N \times \pi r^2 l}{A \times d}$

$$\therefore \frac{N \times \pi r^2 l}{A \times d} = 1 - \varepsilon$$

$$a = \frac{N \times 2\pi r l}{A d}$$

$$a = \frac{\cancel{N} \times 2\pi \cancel{r} \cancel{l}}{\cancel{N} \times \pi r^{\cancel{2}} \cancel{l}} \times (1-\epsilon)$$

$$\boxed{a = \frac{2(1-\epsilon)}{r}}$$

given $a = 30000 \ m^{-1}$

$r = 10 \ \mu$

$\Rightarrow$

$$30000 = \frac{2(1-\epsilon)}{10 \times 10^{-6} \ m}$$

$$\Rightarrow \quad 0.3 = 2(1-\epsilon)$$

$$\boxed{\epsilon = 0.85}$$

$$\epsilon = 1 - \frac{\rho_{apparent}}{\rho_{true}}$$

$$0.85 = 1 - \frac{315}{\rho_{true}}$$

$$\boxed{\rho_{true} = \frac{315}{0.15} = 2100 \ Kg/m^3}$$ Ans

(3)

$$R = \frac{d \xrightarrow{} \text{Thickness}}{A\,K_{eff}}$$

where, $K_{eff} = \frac{K\,\varepsilon}{\tau}$

$K \rightarrow$ bulk conductivity of electrolyte

$\varepsilon \rightarrow$ porosity

$$\therefore \quad R = \frac{d\,\tau}{A\,K\,\varepsilon}$$

$$\therefore \quad \tau = \frac{R \times A \times K \times \varepsilon}{d}$$

$$= \frac{3\,[\Omega] \times 2 \times 10^{-4}\,[m^2] \times \frac{10 \times 10^{-3}}{10^{-2}}\left[\frac{S}{m}\right] \times 0.4\,[-]}{100 \times 10^{-6}\,[m]}$$

$$\boxed{\tau = 2.4}$$

④ Wagner No.

$$W_a = \frac{\text{Reaction Resistance}}{\text{Ohmic Resistance}}$$

$$W_a = \frac{R_{ct}}{R_\Omega} ,$$

Wagner No. is a measure of uniformity of the current density

If $W_a = 0$ $\Rightarrow$ Ohmic losses are high & Current is not uniform.

If $W_a \longrightarrow \infty$ $\Rightarrow$ Reaction Resistance is high $\Rightarrow$ Current is uniform

$W_a = 0$ $\Rightarrow$ $R_{ct} <<< R_\Omega$

$R_{ct} \approx 0$, In this case Rx^n occurs so fast that current distribution is non-uniform

$W_a \to \infty$ $\to$ $R_{ct} >>> R_\Omega$, Rx^n occurs slowly, Uniform Current distribution is obtained.

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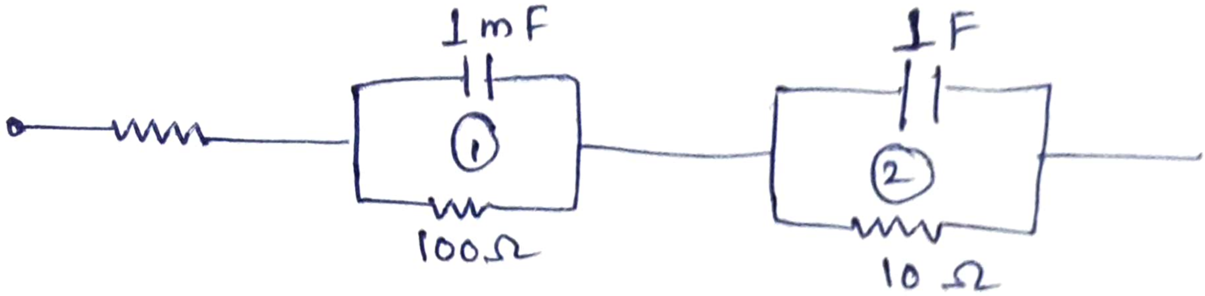

$$\omega_{peak_1} = \frac{1}{R_1C_1} = \frac{1}{100 \times 10^{-3}F}$$

$$2\pi f_1 = \frac{1}{0.1}$$

$$f_1 = 1.59 \text{ Hz}$$

$$\omega_{peak_2} = \frac{1}{1F \times 10\Omega} = 0.1$$

$$2\pi f_2 = 0.1$$

$$f_2 = 0.0159 \text{ Hz} \simeq 15.9 \text{ mHz}$$