UNIVERSITY OF RUHUNA

Faculty of Engineering

Mid-Semester 8 Examination in Engineering: November 2014

Module Number: EE8230 **Module Name: High Voltage Engineering**

[Two Hours]

[Answer **all questions**, each question carries **5 marks**]

Q1 a) i) Tests with Alternating Current (AC) shows, lowest flashover voltage takes place near the peak of the positive half cycle (that is, when the "sharpest" electrode has a positive polarity with respect to the other one). Explain this phenomenal.

ii) For secondary emission of electrons from a cathode, explain the importance of the relationship.

$$W_k + W_p > 2W$$

where, W_k and W_p are the kinetic and potential energies of the positive ion bombarded on the cathode and W is the work function of the metal of which cathode is made.

[2.5 Marks]

b) i) How does electronegativity help SF_6 to become an insulation material for Gas Insulated Substation (GIS)?

ii) Explain high voltage principles behind the recent trend in theft of lightning rods in old estate bungalows in Sri Lanka.

[2.5 Marks]

Q2 a) Explain, with the aid of a voltage-current graph, the processes happening in a gas sample when it is subjected to varying electric field (ignoring secondary effects).

[1 Mark]

b) Explain the importance of positive ion impinging on cathode in ionization of gases. Also show on a graph, how this changes the Townsend's initial model, $I_d = I_0\, e^{\alpha d}$.

[1 Mark]

c) The table Q2(c) gives sets of experimental results for studying Townsend's mechanism. The field is kept constant. Determine the values of Townsend's first and second ionization coefficients. The minimum current observed is 6×10^{-14} A.

Note:

$$I_x = \frac{I_0 e^{\alpha x}}{[1 - \gamma(e^{\alpha x} - 1)]}$$

where,

I_0 - current at cathode

I_x - current at x distance from cathode

α - Townsend's first ionization coefficient

γ - second ionization coefficient

Table Q2(c)

Distance between the gap x (mm)	Current observed I (A)
0.5	1.50×10^{-13}
1	5×10^{-13}
1.5	8.50×10^{-13}
2	1.50×10^{-12}
2.5	5.60×10^{-12}
3	1.40×10^{-10}
3.5	1.40×10^{-10}
4	1.50×10^{-09}
5	7.00×10^{-07}

[3 Marks]

Q3 a) A dielectric liquid of dielectric constant ε_1, has another impurity liquid of dielectric constant ε_2 included. Explain the role played by the ratio $\varepsilon_2/\varepsilon_1$ in breaking down this dielectric liquid.

[1 Mark]

b) List the processes that break down solids in the order of time of application of voltage, and describe two of those processes.

[1.5 Marks]

c) A certain dielectric can be considered to be represented by the equivalent circuit shown in figure Q3(c). What is the maximum voltage that can be applied across the dielectric, if partial discharges in air are to be avoided? State any assumptions made.

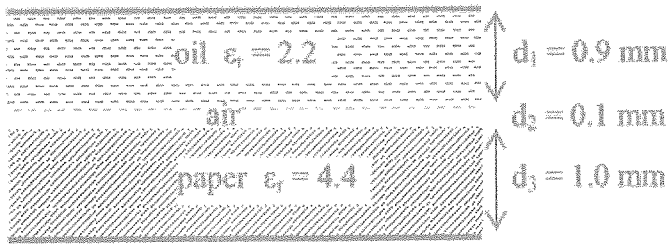

Figure Q3(c)

[2.5 Marks]

Q4 a) Draw a diagram showing the most vulnerable area of a phase conductor for a lightning when the tower has shielding wire at the top. Clearly show the shielding angle of the tower.

[1 Mark]

b) Explain the boundaries of the area.

[1 Mark]

c) Show that the shielding angle θ is a solution of,

$$\theta = \sin^{-1}\frac{r_s - h}{r_s} - \sin^{-1}\frac{H - h}{2r_s\cos\theta}$$

where, r_s is the striking distance, h is the height to the most vulnerable phase conductor from the ground and H is the height to the shielding wire from the ground.

[3 Marks]