1- **Define** the meaning of the electric field and **discuss** the various types of electric field according to the electrode configuration.

2- **Mention** the various methods for electric field computation and discuss the importance of electric field computation.

3- Consider two concentric spheres form a capacitor as apart from GIS; the inner and outer radii are r and R respectively, the potential upon the inner sphere is V.
   a) **State** the expression for the electric field and the potential at any radius x and then draw them with radius x.
   b) **Derive** the expressions for the maximum value and minimum value of electric field.
   c) **Derive** the field enhancement factor.
   d) **Derive** the inner radius of the inner sphere at which Emax has a minimum value.
   e) **Derive** the capacitance of the concentric sphere.

4- Consider a pair of coaxial cylindrical electrodes as apart from GIS, the potential upon the inner electrode is V, the inner electrode radius is r where the outer radius of the enclosure is R, the length of the cylinder is L.
   a) **State** the expression for the electric field and the potential at any radius x and then draw them with radius x.
   b) **Derive** the expressions for the maximum value and minimum value of electric field.
   c) **Derive** the field enhancement factor.
   d) **Derive** the optimal radius of the inner electrode at which Emax has a minimum value.
   e) **Derive** the capacitance of the coaxial cylindrical electrodes.

1. A beam of ions is injected into a gas. The beam has an initial density $n_o$ ions/cm$^3$. **Find** the density of the remaining ions at a distance equal to (a) the mean free path, (b) five times the mean free path.

2. In an experiment to measure $\alpha$ for a certain gas, it was found that the steady state current is 5.5 x $10^{-8}$ A at 8 kV at a distance of 0.4 cm between the plane electrodes. Keeping the field constant and reducing the distance to 0.1 cm results in a current of 5.5 x $10^{-9}$ A. **Calculate**:
   a) Townsend's primary ionization coefficient α.
   b) The number of electrons emitted from the cathode per second.
   c) The electrode spacing that would result an electron avalanche of $10^2$.

3. In an experiment in a certain gas it was found that the current between two Parallel plates were 1.22, 1.82 and 2.22 of the initiating photocurrent at distances 0.005, 0.01504 and 0.019 m respectively. E/P and P were maintained constant at 160 V/cm.torr, 0.1 torr respectively**.** **Calculate:**
   a) Townsend's primary ionization coefficient α.
   b) The secondary ionization coefficient γ.
   c) The ionization efficiency.
   d) The distance and the voltage at which transition to self sustained (breakdown) take place.

4. The following table gives two sets of experimental results for studying Townsend's mechanism. E is kept constant in each set. The minimum current observed is 6 × $10^{-14}$ A. **Determine** the values of Townsend's first and second ionization coefficients for each set.

| *I set 30 kV/cm* *Gap distance (mm)* | *II set kV/cm* *Observed current A* | |
|---|---|---|
| | *I set* | *II set* |
| 0.5 | $1.5 \times 10^{-13}$ | $6.5 \times 10^{-14}$ |
| 1.0 | $5 \times 10^{-13}$ | $2.0 \times 10^{-13}$ |
| 1.5 | $8.5 \times 10^{-13}$ | $4 \times 10^{-13}$ |
| 2.0 | $1.5 \times 10^{-12}$ | $8 \times 10^{-13}$ |
| 2.5 | $5.6 \times 10^{-12}$ | $1.2 \times 10^{-12}$ |
| 3.0 | $1.4 \times 10^{-10}$ | $6.5 \times 10^{-12}$ |
| 3.5 | $1.4 \times 10^{-10}$ | $6.5 \times 10^{-11}$ |
| 4.0 | $1.5 \times 10^{-9}$ | $4.0 \times 10^{-10}$ |
| 5.0 | $7.0 \times 10^{-7}$ | $1.2 \times 10^{-8}$ |

5. If an electron starts at a distance of 0.5 mm in a field where α = b-ax cm-1, **Find** the distance it must travel to produce an avalanche of $10^2$ electrons where a=10*$10^3$ and b=3.5*$10^3$.

6. **Repeat** the above problem if an electron starts at x=5mm.

7. For the field given in the previous problem, **Determine** the minimum distance from the anode, from which an electron start an avalanche having a total no of electrons of $10^2$.

1. **Calculate** the number of electrons formed in an electron avalanche which has traveled a distance of 1.5cm in the uniform field gap between two parallel plates provided that in air at the given field the values of the ionization and the attachment coefficient are $\alpha$=7.4 , $\mu$=5 , $\eta$=2.4 The electron avalanche has started by an electron flash of 100 electrons.

2. **Calculate** the value of secondary ionization coefficient that fulfills Towensed criterion of breakdown in a uniform gap of 2 cm width, which stressed by a uniform field corresponding to $\alpha$=8.

3. **State** Townsend criterion of breakdown in gases. In a certain gas at low pressure, if the first ionization coefficient ($cm^{-1}$) is related to E (volt/cm) by the expression $\alpha=(E/200)^{4.35}*10^{-6}$ and if the second Townsend coefficient has a value of $10^{-4}$, **Calculate** the electrode spacing necessary to produce breakdown and the breakdown voltage assuming that E is constant at 8 kV/cm.

4. If the breakdown voltage of two parallel plates separated by a gap of 0.1cm is 4500V, **Calculate** the total secondary coefficient of ionization $\gamma$ if the gap is air at a pressure 760 torr and temperature of $25^{o}$ C. Take A=15$cm^{-1}$ and B=365 .

5. If the voltage of two parallel plates separated by air gap of 0.002 m is 9 Kv just before the transition to self sustaining current. **Calculate** The total secondary ionization coefficient $\gamma$ at NTP (P=1 atm. = 101.3 Kpa ). The A and B values are 11253.7 $(m.Kpa)^{-1}$, 273840 (v/m.Kpa) respectively.

6. For a certain gas the first Townsend coefficient of ionization is given by the standard equation with A=15 $(cm)^{-1}$ and B=365. If the secondary ionization coefficient is equal to $10^{-4}$, **Calculate** the minimum breakdown voltage and the minimum value of the pressure distance product.

7. For a certain gas, if A=15 $(cm.torr)^{-1}$ and B=365 (v/cm.torr). E/P is kept constant to be 350 V/cm.torr and P is kept constant to be 5 torr. **Calculate**:
   a) The First Townsend's ionization coefficient $\alpha$
   b) The mean free path $\lambda$.
   c) The ionization potential.
   d) The maximum ionization efficiency.
   e) If $\gamma=10^{-4}$ calculate the minimum breakdown voltage and the corresponding value of the pressure-distance product.

8. For the current growth equation of Townsend's Criterion for breakdown in Gases with second ionization process;
   a) **Mention** the Townsend's Criterion for breakdown in Gases?
   b) **What** are the drawbacks of Townsend's Criterion for breakdown in Gases?
   c) **Define** Townsend's first and second ionization coefficients?
   d) **Mention** the condition for breakdown in a Townsend discharge?
   e) **Define** Paschen's law for breakdown in Gases?
   f) **Mention** how you account the breakdown voltage as a function in "p x d "?
   g) **Mention** how you account the minimum voltage for breakdown under a given "p x d " condition?

9. **Write** a short notes on each of the following:
   a) Photo ionization Process.
   b) Photoemission Process.
   c) Electron attachment.
   d) Self sustained discharge.
   e) Electronegative gases.
   f) Non self sustained discharge.
   g) The various factors which affect breakdown of gases.

10. **Why** is the breakdown strength higher in electronegative gases compared to that in other gases?

11. **Mention** the Townsend's criterion for breakdown in electronegative gases?

12. **Explain** with drawing the streamer theory of breakdown in gases?

1) Transformer oil having a dielectric constant of 2.2 and a dielectric strength of 25 kV/mm, is used as an insulation of spacing 8 mm. **Determine** the maximum applicable voltage. A barrier of thickness 3 mm of transformer board with a dielectric strength of 50 kV/mm, dielectric constant of 4.4 is used in this space to increase the strength. **Does** the transformer board serve this purpose in this case?

2) In an experiment for determining the breakdown strength of transformer oil, the following observations were made. **Determine** the power law dependence between the gap spacing and the applied voltage of the oil.

| | | | | |
|---|---|---|---|---|
| Gap spacing (mm): | 4 | 6 | 10 | 12 |
| Voltage at breakdown(kV): | 90 | 140 | 210 | 255 |

3) A solid specimen of dielectric has a dielectric constant of 4.2, and tan $\delta$ as 0.001 at a frequency of 50 Hz. If it is subjected to an alternating field of 50 kV/cm, **Calculate** the heat generated in the specimen due to the dielectric loss.

4) A solid dielectric specimen of dielectric constant of 4.0, has an internal void of thickness 1 mm. The specimen is 1 cm thick and is subjected to a voltage of 80 kV (rms). If the void is filled with air and if the breakdown strength of air can be taken as 30 k V (peak)/cm, **Find** the voltage at which an internal discharge can occur.

5) **What** is "thermal breakdown" in solid dielectrics, and how is it practically more significant than other mechanisms?

6) **Explain** the different mechanisms by which breakdown occurs in solid dielectrics in practice. Then discuss how does the "internal discharge" phenomena lead to breakdown in solid dielectrics?

7) **What** are the demerits of liquids with solid impurities?

8) **Mention** the different recommendations and requirements which required during testing transformer oil for dielectric strength, and then **mention** the accepted value of dielectric strength for transformer oil?

9) **Mention** the different factors which affecting on the BDV for insulating Gases, liquids, and solids?

1) **Compute** the ground resistance for a hemisphere of 0.5, 1 and 2m diameter, at distances 2m, 10m and 100m from the center of the sphere. **Present** the results in both tabular and graphical formats and for different soil composition.

2) **Calculate** the ground resistance and the overlapping coefficient for the grounding system shown below in each figure, given that the earth resistivity ρ=100 Ω.m, the length of the driven rod is 8 m, and its diameter is 6 cm. **Discuss** your results.

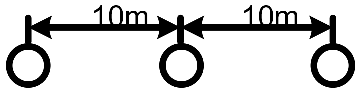


Fig. 1

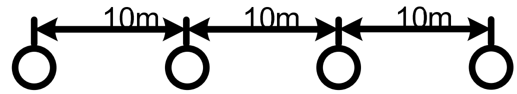


Fig. 2

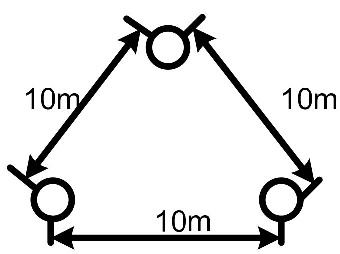


Fig. 3

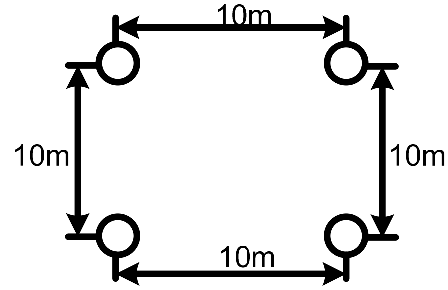


Fig. 4

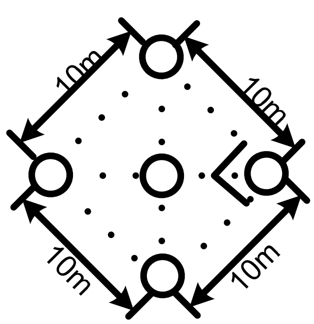


Fig. 5

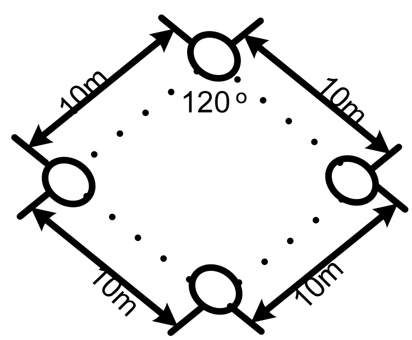


Fig. 6

3) If the earth resistance of a driven rod is 5 Ω, and its diameter is 5 cm, **Calculate** the length of the driven rod, given that the earth resistivity ρ=100 Ω.m.