Example

As shown, the following table gives the sets of observations obtained while studying the Townsend phenomenon in a gas. Compute the values of the Townsend's primary and secondary ionization coefficients from the data given.

Set 1:									
Gap distance (mm)	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0
Applied voltage V (volts)	1000	2000	3000	4000	5000	6000	7000	8000	10000
Observed current I (A)	10^{-13}	3×10^{-13}	6×10^{-13}	10^{-12}	4×10^{-12}	10^{-11}	10^{-10}	10^{-9}	5×10^{-7}
Set 2:									
V (volts)	500	1000	1500	2000	2500	3000	3500	4000	4500
I (A)	5×10^{-14}	1.5×10^{-13}	3×10^{-13}	6×10^{-13}	10^{-12}	5×10^{-12}	5×10^{-11}	3×10^{-10}	10^{-8}

The minimum current observed when 150 V was applied was 5×10^{-14} A.

Solution

The current at minimum applied voltage, I_0, is taken as 5×10^{-14} A, and

The values of $\log I/I_0$ versus d for two values of electric field, $E_1 = 20$ kV/cm and $E_2 = 10$ kV/cm are given in Table **below**

Table **given**

Set 1:									
Gap distance (mm)	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0
Applied voltage V (volts)	1000	2000	3000	4000	5000	6000	7000	8000	10000
Observed current I (A)	10^{-13}	3×10^{-13}	6×10^{-13}	10^{-12}	4×10^{-12}	10^{-11}	10^{-10}	10^{-9}	5×10^{-7}
Set 2:									
V (volts)	500	1000	1500	2000	2500	3000	3500	4000	4500
I (A)	5×10^{-14}	1.5×10^{-13}	3×10^{-13}	6×10^{-13}	10^{-12}	5×10^{-12}	5×10^{-11}	3×10^{-10}	10^{-8}

Table **calculated**

	Gap (mm)	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	5.0
Set 1:	I/I_0 for $E_1 = 20$ k V/cm	2	6	12	20	80	200	2×10^3	2×10^4	5×10^7
	$\log I/I_0$	0.3010	0.7181	1.0792	1.3010	1.9031	2.3010	3.3010	4.3010	7.6990
Set 2:	I/I_0 for $E_2 = 10$ k V/cm	1	3	6	12	20	100	1000	6000	2×10^5
	$\log I/I_0$	0	0.4771	0.7781	1.0792	1.3010	2.0	3.0	3.7781	5.3010

Solution

the graph of d versus log I/I_0 is plotted as shown in Fig. below

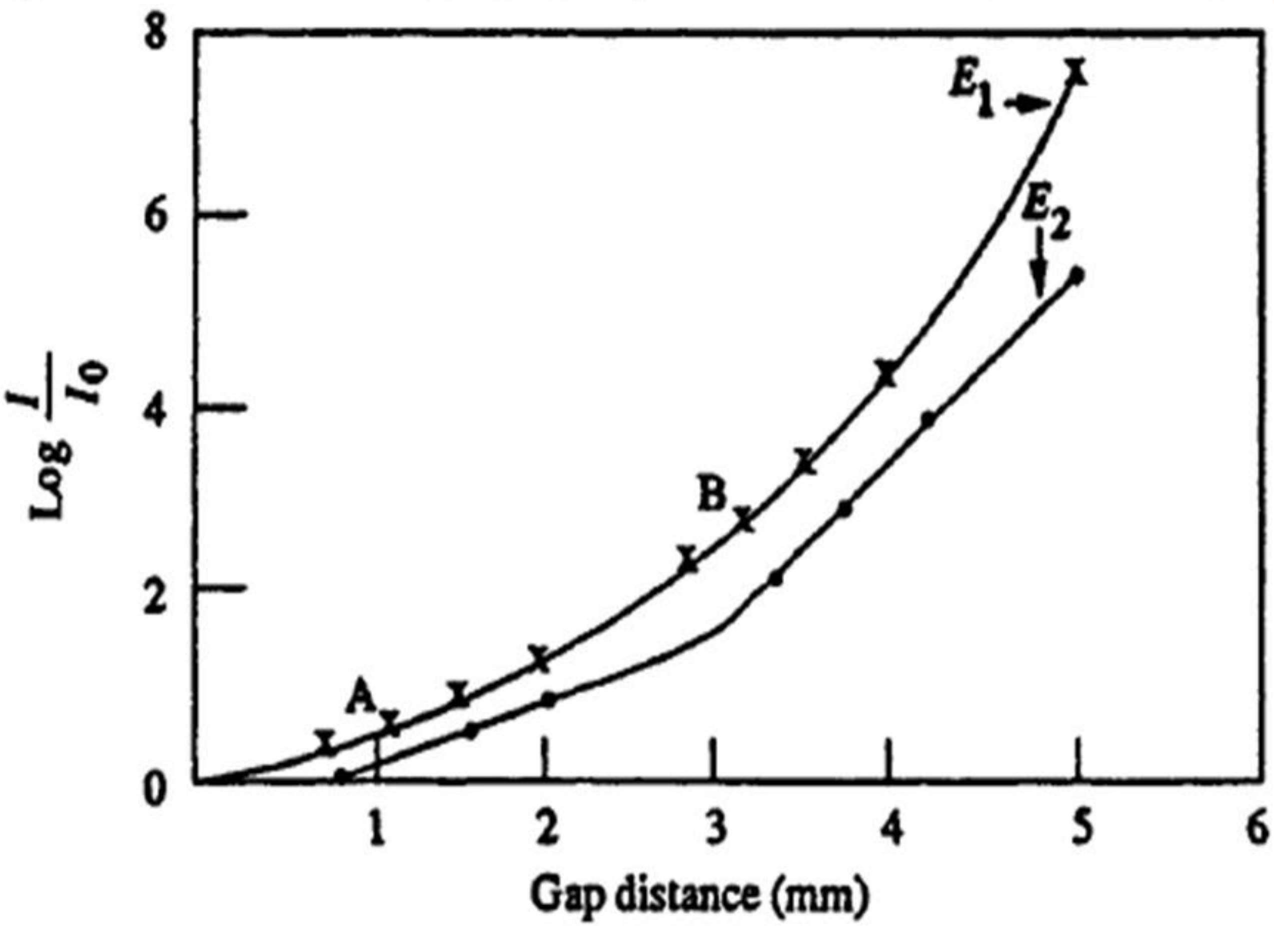
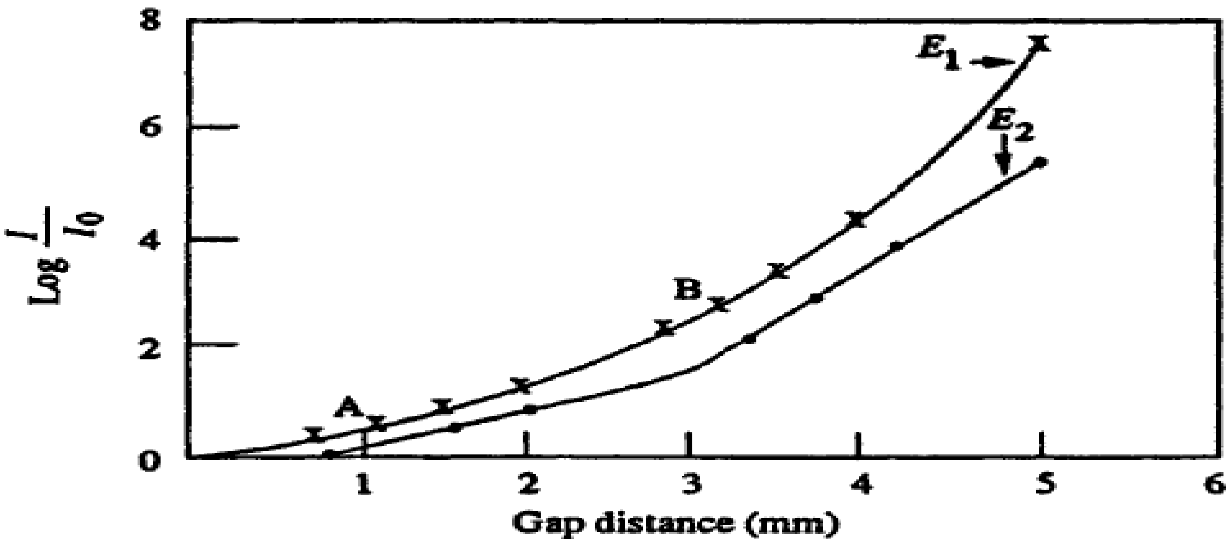


Fig. Log I/I_0 as a function of gap distance

Solution



Value of α at E_1(= 20 kV/cm) i.e. α_2 = slope of curve E_1

$$= \frac{2.9}{2.5 \times 10^{-1}}$$

$$= 11.6\ \text{cm}^{-1}\ \text{torr}^{-1}$$

Value of α at E_2 (= 10 kV/cm) i.e. α_1 = slope of curve E_2

$$= \frac{13}{2 \times 10^{-1}}$$

$$= 6.5\ \text{cm}^{-1}\ \text{torr}^{-1}$$

Solution

As the sparking potential and the critical gap distance are not known, the last observations will be made use in determining the values of γ.

For a gap distance of 5 mm, at $E_1 = 20$ kV/cm,

$$I = \frac{I_0 \exp(\alpha d)}{1 - \gamma[\exp(\alpha d) - 1]}$$

$$\frac{I}{I_0} = \frac{\exp(\alpha d)}{1 - \gamma[\exp(\alpha d) - 1]}$$

Substituting $\alpha_1 = 11.6$, $d = 0.5$ cm, and $I/I_0 = 5 \times 10^7$

$$5 \times 10^7 = \frac{\exp(5.8)}{1 - \gamma[\exp(5.8) - 1]}$$

$$= \frac{330.3}{1 - \gamma(330.3 - 1)}$$

or $$\gamma = 3.0367 \quad 10^{-3}/\text{cm}.\text{torr, at } E_1 = 20 \text{ kV/cm}$$

(Check this value with other observations also.)

Solution

For $E_2 = 10\,kV/cm$

$\alpha_2 = 6.5/cm\,.\,torr$

$d = 0.5\,cm$

and $I/I_0 = 2 \times 10^5$

Substituting these values in the same equation,

$$2 \times 10^5 = \frac{\exp(3.25}{1\gamma\,[\exp(3.25) - 1]}$$

$$= \frac{25.79}{1 - \gamma\,(25.79 - 1)}$$

or, $\gamma = 4.03 \times 10^{-2}/cm\,.\,torr$, at $E_2 = 10\,kV/cm$