Applications Aspects of the Diffusion of Slow Electrons in the Ionospheric Gases

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Abstract:

The paper presents the results of precise of the calculations of the diffusion of slow electrons in ionospheric gases, such as, (Argon – Hydrogen mixture, pure Nitrogen and Argon – Helium – Nitrogen) in the presence of a uniform electric field and temperature 300 Kelvin. Such calculations lead to the value Townsend's energy coefficient (K_T) as a function of E/P (electric field strength/gas pressure), electric field (E), electric drift velocity (V_d), momentum transfer collision frequency (ν_m), energy exchange collision frequency (ν_u) and characteristic energy (D/μ).

The following physical quantities are deduced as function s E/P: mean free path of the electrons at unit pressure, mean energy lost by an electron per collision, mean velocity of agitation and the collisional cross-section of the molecules. The results are presented graphically and in tabular form. This results appeared a good agreement with the experimental data.

Key words: Boltzmann relation (Plasma Physics), Maxwell speed distribution, Gas discharge laser.

Introduction:

An account of theoretical and experimental investigation of the motions of slow electrons in air using a modification of the well-known diffusion method of Townsend of analyzing the lateral diffusion of a stream of electrons. Electrons generated by a heated filament enter the diffusion chamber through a small hole in the upper electrode and move in electric field in a steady state of motion through the gas to the lower electrode, the hole behaves as a doublet source. The mathematical expression for the distribution of the current over the receiving electrode is relatively simple [1-6].

For their procedure is the use of different average of the agitational speeds U of the electrons in the form dimensionless factors.

This type lead to the determination of the quantities experimentally, which is: Townsend's energy factor, the drift velocity of the electrons, the root-mean-square velocity of agitation of the electrons, the mean free path of the electrons at unit pressure, the collisional cross-section of the molecules for slow electrons and the mean proportion of its energy lost per collision by an electron to molecule.

Theoretical of this type lead to the determination of the above physical quantities. In this paper we found this quantities as indicate in the tabular form.

The importance of these physical quantities in related field of study, such as, the ionosphere, the measurements of them should be possible [7].

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Materials and Methods:

E	Applied electric field, in unit of V/cm.
V/cm	Volt/Centimeters.
U	Electron energy, in unit of eV.
eV	Electron volt.
N	Number of gas molecules, in unit of cm^{-3}.
Q_m	Momentum transfer cross section of electron-molecule collision, in cm^2.
Q_j	Rotational, vibrational, or electronic excitation cross section, in cm^2.
f(u)	Steady-state distribution function for electrons, in $eV^{-3/2}$.
Q_{-j}	Collision cross section in which electron gains the energy u_j , in cm^2.
e	Electronic charge, in coulomb, $=1.602\times10^{-19}$C.
m	Electron mass, in unit of gm, $=9.109\times10^{-28}$ gm.
M	Molecular mass, in gm.
K	Boltzmann constant $=1.38\times10^{-23}$ J/°K.
J	Joule.
°K	Kelvin degree.
°C	Centicreate degree.
v	Electron speed, in unit of cm/sec.
Q_0	Value of Q_m at some reference energy.
L	Mean free path of the electron at unit pressure (1 mm Hg), in unit of cm.
$\bar{U}$	Mean speed in agitational motion, in unit of, cm/sec.
V_d	Electron drift velocity, in unit of, cm/sec.
D	Electron diffusion coefficient, in unit of, cm^2/sec.
R_0	Gas constant=8.3143J/(°Kmol).
T	Gas temperature, °K.
N_A	Avogadro's number $= 6.023\times10^{23}$ atom/mol.
K_T	Townsend's energy factor, in unit of, eV.
η	Mean proportion of energy lost by an electron per collision.
Q	Mean agitational energy of an electron.
Q_T	Mean agitational energy of a gas molecule.
ν_m	Momentum transfer collision frequency.
ν_u	Energy exchange collision frequency.
A	Effective cross-section of gas molecules for collision, cm^2.
Max.	Maxwell distribution.
Druy.	Druyvesteyn distribution.

Boltzmann transport equation solution:

Assume a swarm of electrons drifting through a gas at temperature T under the influence of a uniform electric field E, in V/cm. The Boltzmann equation is [8]:

$$\frac{E^2}{3}\frac{d}{du}\left(\frac{u}{NQ_m}\frac{df}{du}\right)+\frac{2m}{M}\frac{d}{du}\left(u^2NQ_m f\right)+$$

$$\frac{2mKT}{Me}\frac{d}{du}\left(u^2NQ_m\frac{df}{du}\right)+$$

$$\sum_j (u+u_j)\,f(u+u_j)NQ_j(u+u_j)$$

$$-uf(u)N_j\sum_j Q_j(u)+$$

$$\sum_j (u-u_j)\,f(u-u_j)NQ_{-j}(u-u_j)-$$

$$uf(u)N_j\sum_j Q_{-j}(u)= \quad (1)$$

Where, u is the electron energy in electron volts which is:

$$u=\frac{mv^2}{2e}\ldots(2)$$

The last two terms express the effect of collision of the second kind, Q_{-j} is defined as the cross section for a collision in which the electron gains the energy u_j . For computation purpose, we make the substitutions:

$$Z=\frac{eu}{KT},\qquad \theta=\frac{Q_m(u)}{Q_0},$$

$$\alpha = \frac{M}{6m}\left(\frac{eE}{NQ_0 KT}\right)^2,$$

$$\eta_{\pm j} = \frac{MQ_{\pm j}}{2mQ_0} \quad \ldots(3)$$

At some reference energy Q_0 is the value of Q_m . The balancing between collision of the first and second kind, we have:

$(Z-Z_j)\eta_{-j}(Z-Z_j) = \exp(-Z_j)Z\ \eta_j(Z)$ for $Z \geq Z_j$

We can obtain the following difference-differential equation by using the Boltzmann relation for relative population of various excited states:

$$\left(\frac{\alpha}{\theta}+Z\theta\right)Z\frac{df}{dZ}+Z^2\theta f+\sum_j\int_Z^{Z+Z_j} Z\eta_j(Z)[f(Z)-$$
$$\exp(-Z_j f(Z-Z_j))]dZ = 0\ldots(4)$$

It is convenient to discuss the experimentally determined quantities, we have chosen to consider only the commonly measured transport coefficients, such as, the diffusion coefficient D, electron mobility μ and drift velocity V_d .

The relations used to calculate the above transport coefficients are [8]:

$$D = \frac{2(KT/m)^{\frac{1}{2}}}{3NQ_0}\int_0^\infty \frac{Z}{\theta} f(Z)dZ \quad \ldots\ (5)$$

$$\mu = \frac{e(2/(KTm))^{\frac{1}{2}}}{3NQ_0}\int_0^\infty f(Z)\frac{d}{dZ}\left(\frac{Z}{\theta}\right)dZ$$

$$= -\frac{e(2/(KTm))^{\frac{1}{2}}}{3NQ_0}\int_0^\infty \frac{Z}{\theta}\frac{df}{dZ}dZ\ldots\ (6)$$

where

$$\int_0^\infty Z^{\frac{1}{2}} f(Z)dZ = 1$$

We can find the mobility from the time of flight of electrons between two electrodes of drift tube, i.e., the mobility is:

$$u = \frac{V_d}{E}\ \ldots(7)$$

The quality D/ μ is usually determined using the Townsend method [9].

Calculations of the input data:

(a) Use a digital computer to solve the appropriate Boltzmann transport equation (1) and evaluate the diffusion coefficient D/ μ, Equation (5), the mobility μ Equation (6) and electron drift velocity V_d, Equation (7) for the assumed input cross sections (momentum transfer cross section for electron-molecule collision, rotational, vibrational, or electronic excitation cross sections) [10], which are fed to our computer program.

(b) Compare appropriate combinations of the computed values of D and μ with the experimental values [4, 11].

(c) We have a good agreement between the computed and measured values of μ and D/ μ as a function of the experimental parameters.

(d) D/ μ has the dimensions of energy as can be seen from equations (5) and (6) and in case of a Maxwellian energy distribution is equal to the quantity: $\frac{D}{\mu} = \frac{KT_e}{e}\ldots(8)$

Where T_e is the electron temperature. Thus, D/μ is an experimentally significant measure of the average energy of the electrons and we call it the "characteristic energy".

(e) We can find the effective frequency for momentum transfer or "elastic" collisions, ν_m, which is defined by the relation [8]:

$$\frac{\nu_m}{N} = \frac{e}{m\mu N} = \frac{e}{m}\frac{E/N}{V_d}\ldots(9)$$

The values of $\frac{\nu_m}{N}$ as a function of an experimental quantity which measures the electron energy, i.e., D/μ.

(f) The power input per electron due to the electric field, V_d eE, is equal to the frequency of energy exchange collisions ν_u times the excess of the electron energy over its thermal equilibrium value. If we take D/ μ as our measure of the electron energy, then:

$$\frac{\nu_u}{N} = \frac{V_d \frac{E}{N}}{\frac{D}{\mu} - \frac{KT}{e}} \ \ldots \ (10)$$

the values of the energy exchange collision frequency $\frac{\nu_u}{N}$ as a function of the characteristic energy D/ μ.

(g) The gases used in this work are (1)- Argon-Hydrogen mixture. (2)- Pure Nitrogen gas. (3)- Argon-Helium-Nitrogen mixture at different percentage.

(h) We constructed the "computer program" as seen in appendix to calculate the equations which is to calculate electron diffusion motion parameters in the gases according to the Maxwell and Druyvesteyn law distribution.

(i) The results are obtained from the above (a-f) are fed to our computer program item (h).

(j) The results obtained from our "computer program" are tabulated and graphically as in figures (1-12).

Calculations of output parameters figures (1-12):

(a) The parameter V_d/D:

We use the kinetic theory of gases to convert the macroscopic quantities V_d and D to the microscope parameters of the electronic motion. In this case we can assume the electrons and molecules are to collide as rigid particles by using the free paths method. The relations for this are [7]:

$$D = \frac{1}{3} L \bar{U} \ldots (11)$$

$$V_d = \frac{2}{3} E \left(\frac{e}{m}\right) L \overline{U^{-1}} \ldots (12)$$

The mean agitational energy of a gas electrons Q is:

$$Q = \frac{1}{2} m \overline{U^2} \quad \ldots (13)$$

The mean agitational energy of a gas molecules Q_T is:

$$Q_T = \frac{3 R_0 T}{2 N_A} \ldots (14)$$

And the Townsend's energy factor K_T is:

$$K_T = \frac{Q}{Q_T} \ldots (15)$$

From Equation (15) we can write:

$$Q = K_T Q_T \ldots (16)$$

Substitut e Equation (14) into Equation (16) obtained:

$$Q = \frac{3 K_T R_0 T}{2 N_A} \quad \ldots (17)$$

By equating equations (13) and Equation (17) yield:

$$\frac{3 K_T R_0 T}{2 N_A} = \frac{1}{2} m \overline{U^2} \ldots (18)$$

$$\frac{1}{2} m = \frac{3 K_T R_0 T}{2 N_A \overline{U^2}} \ldots \ (19)$$

By dividing equations (12) to Equation (11) yield:

$$\frac{V_d}{D} = \frac{\frac{2}{3} E \frac{e}{m} L \overline{U^{-1}}}{\frac{L \overline{U}}{3}} = 2E \frac{e}{m} \frac{\overline{U^{-1}}}{\overline{U}}$$

$$= \frac{eE}{\frac{1}{2} m} \frac{\overline{U^{-1}}}{\overline{U}} \ldots (20)$$

Substitute Equation (19) into Equation (20) yield:

$$\frac{V_d}{D} = \frac{eE}{\frac{3 K_T R_0 T}{2 N_A \overline{U^2}}} \frac{\overline{U^{-1}}}{\overline{U}}$$

$$= \frac{N_A eE}{\frac{3}{2} K_T R_0 T} \frac{1}{\left[\frac{\overline{U}}{\overline{U^2}} \overline{U^{-1}} \right]} \ldots (21)$$

Put:

$$K_1=\frac{3}{2}\left[\frac{\overline{U}}{\overline{U^2}}\overline{U^{-1}}\right]K_T \quad \ldots(22)$$

Substitute Equation (22) into Equation (21) yield:

$$\frac{V_d}{D}=\frac{N_A eE}{R_0 T K_1} \quad \ldots(23)$$

where K_1 is the measured quantity.

From the following relation, we can find:

°T = (273 + °C) °K at gas temperature equal 27°C, then;

°T = (273 + 27) = 300 °K

and

$N_A = 6.023 \times 10^{23}$ atom mol^{-1} , $R_0 = 8.3143$ J $°K^{-1}$ mol^{-1}, $e = 1.602 \times 10^{-19}$ C

Substitute the above constants into Equation (23) yield:

$$\frac{V_d}{D}=38.7\frac{E}{K_1}\ldots(24)$$

(b) The parameter K₁:

We can define the parameter K_1 which is the drift of the characteristic energy D/µ to the thermal equilibrium energy K T_g/e, which is from Equation (8) obtained:

$$K_1=\frac{\frac{D}{\mu}}{\frac{KT_g}{e}}=\frac{e}{KT_g}\frac{D}{\mu}\ldots(25)$$

(c) The Townsend's energy factor K_T: From the item (b) the parameter K_1 is called the quantity measured and the actual value of K_T depends on the velocity distribution, which is:

$$K_T=\frac{3}{2}\left[\frac{\overline{U}}{\overline{U^2}}\overline{U^{-1}}\right]K_1\ldots(26)$$

where [9]:

$$\left[\frac{\overline{U}}{\overline{U^2}\,\overline{U^{-1}}}\right]=\frac{2}{3} \quad \ldots(27)$$

$$\left[\frac{\overline{U^2}\,\overline{U^{-1}}}{\overline{U}}\right]=\frac{3}{2} \quad \text{for Maxwell} \ldots (28)$$

$$=1.312 \quad \text{for Druyvesteyn} \quad \ldots (29)$$

Substitute Equation (28) into Equation (26) yield:

$$K_T=\frac{2}{3}\left[\frac{3}{2}\right]K_1=K_1 \text{for} \quad \text{Maxwell} \quad \ldots(30)$$

Substitute Equation (29) into Equation (26) yield:

$$K_T=\frac{2}{3}[1.312]K_1=0.8746K_1$$

$$=0.875K_1 \text{ for Druyvesteyn} \quad \ldots(31)$$

(d) The mean velocity of agitation $\overline{U}$: The root mean square velocity is:

$$\left(\overline{U^2}\right)^{\frac{1}{2}}=1.15\times10^7(K_T)^{\frac{1}{2}}\ldots(32)$$

$$=0.947\times10^7\left[\frac{\overline{U^2}\,\overline{U^{-1}}}{\overline{U}}\right]^{\frac{1}{2}}(K_1)^{\frac{1}{2}}\ldots(33)$$

and

$$\overline{U}=\left(\overline{U}\left(\overline{U^2}\right)^{-\frac{1}{2}}\right)^{\frac{1}{2}}(\overline{U^2})^{\frac{1}{2}} \quad \ldots(34)$$

where

$$\left(\overline{U}\left(\overline{U^2}\right)^{-\frac{1}{2}}\right)=0.85 \text{ for Maxwell} \quad \ldots(35)$$

$$=0.95 \quad \text{for} \quad \text{Druyvesteyn} \quad \ldots(36)$$

from the above equations we can find $\overline{U}$:

$$\overline{U}=1.06\times10^7\left(K_1\right)^{\frac{1}{2}} \quad \text{for} \quad \text{Maxwell} \quad \ldots(37)$$

$$\overline{U}=1.02\times10^7\left(K_1\right)^{\frac{1}{2}} \quad \text{for Druyvesteyn} \quad \ldots(38)$$

(e) The mean free path in unit of pressure:

We can define the mean free path of the electron at unit pressure (1 mm Hg) like this:

$$L = 8.02\times10^{-9}\left(V_d\,(E/P)\right)\left(K_1\right)^{\frac{1}{2}}\left[\overline{U}\ \overline{U^{-1}}\right]^{-\frac{1}{2}} \quad ...(39)$$

where

$$\left[\overline{U}\ \overline{U^{-1}}\right] = \frac{4}{\pi} = 1.27 \quad \text{Maxwell} \ldots \ (40)$$

$$= 1.18 \quad \text{Druyvesteyn} \ \ldots \ (41)$$

Substitute Equation (40) into Equation (39) yield:

$$L = 7.116\times10^{-9}\left(V_d\,(E/P)\right)\left(K_1\right)^{\frac{1}{2}}$$

Maxwell … (42)

$$L = 7.383\times10^{-9}\left(V_d\,(E/P)\right)\left(K_1\right)^{\frac{1}{2}}$$

Druyvesteyn …(43)

(f) The mean proportion of energy lost by an electron per collision (η):

The mean proportion η of its energy lost per collision by an electron to a molecule as a function of E/P or some other convenient variable is:

$$\eta = \frac{3.4\times10^{-14}V_d^2}{\overline{U^2}\left(\overline{U^{-1}}\right)^2 K_1}$$

, by using Equation (32) and equations (40-41) obtained:

$$\eta = 1.79\times10^{-14}\,\frac{V_d^2}{K_1} \quad \text{Maxwell} \ \ldots(44)$$

$$\eta = 2.21\times10^{-14}\,\frac{V_d^2}{K_1} \ \text{Druyvesteyn}\ldots \ (45)$$

(g) Empirical formula for η as a function of K$_T$:

The mean energy transferred from an electron in collision with an air molecule is proportional to the mean energy excess (Q-Q$_T$) for the interaction of radio waves in the ionosphere. Thus:

$$\Delta Q = \eta Q = G(Q - Q_T)$$

where G is a constant. i.e.

$$\eta K_T = G(K_T - 1) \ldots(46)$$

and

$$G = \frac{\nu_m}{\nu_u} \ldots(47)$$

Substitute Equation (30) and Equation (47) into Equation (46) yield:

$$\eta K_T = \frac{\nu_m}{\nu_u}\left(K_1 - 1\right) \quad \text{Maxwell} \ \ldots(48)$$

Substitute Equation (31) and Equation (47) into Equation (46) yield:

$$\eta K_T = \frac{\nu_m}{\nu_u}\left(0.875K_1 - 1\right) \text{Druyvesteyn}$$

…(49)

(h) Effective cross section A:

Considering the gas molecule to behave in collisions as a rigid particle then the effective cross section of gas molecules for collision A is:

$$A = \frac{1}{n\ L} = \frac{1}{n_1 L} \quad ...(50)$$

where

n = n$_1$ = number of molecules/cm^3, L = mean free path at unit pressure, P, 1 mm Hg., at P = 1 mm Hg, °T = 300 °K, then:

n = n$_1$ = 3.22 × 10^{16} cm^{-3} …(51)

Substitute Equation (42) and Equation (51) into Equation (50) yield:

$$A = \frac{1}{3.22\times10^{16}\times7.116\times10^{-9}\times\frac{V_d(K_1)^{\frac{1}{2}}}{E/P}}$$

……… Maxwell …(52)

Substitute Equation (43) and Equation (51) into Equation (50) yield:

$$A = \frac{1}{3.22\times10^{16}\times7.383\times10^{-9}\times\frac{V_d(K_1)^{\frac{1}{2}}}{E/P}}$$

……….. Druyvesteyn …(53)

Results and Discussion:

In this job we study the diffusion of slow electrons in Argon-Hydrogen, pure Nitrogen, and Argon-Helium-Nitrogen mixture. The results obtained agree with the references, such as, Ref. [7].

Figs (1-3) show the Townsend's energy factors as a function of the applied electric field to the gas pressure ratio for Argon-Hydrogen, pure Nitrogen, and Argon-Helium-Nitrogen mixture which are a good agreement with those obtained by Ref.

[7], this mean, increasing the K_T with increasing of E/P.

Figs (4-5) show the mean free path at unit pressure (L) versus mean velocity of agitation $\bar{U}$ for Argon-Hydrogen, pure Nitrogen, and Argon-Helium-Nitrogen mixture, this mean, the mean free path decreases with increasing of the $\bar{U}$. The expressions for both $\bar{U}$ and L depends on the temperature of the gas and the values are shown in figs. (4-5). are calculated for 300 Kelvin and P=1 mm Hg = 1 Torr.

Figs (6-9) show the mean proportion of the energy lost by an electron per collision (η) plotted as a function of the Townsend's energy factor (K_T) for Argon-Hydrogen mixture for T=300 °K, which is seen the mean of energy lost (η) increased with increasing of the Townsend's energy factor (K_T).

Fig (10), in which ηK_T is plotted against K_T, indicates that the empirical formula for η as a function of K_T is closely followed in Hydrogen for low values of E/P (assuming a Maxwell distribution). In Nitrogen, however, the formula appears to be only approximately true with a value of G.

Figs (11-12) show the effective cross-section of gas molecules for collision (A) plotted against $\bar{U}$, which is seen, the increasing of A with increasing of $\bar{U}$ for different mixtures.

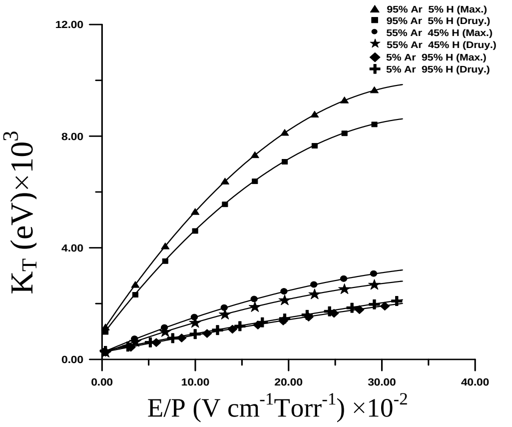

Fig. (1): The Townsend's energy factors as a function of the ratio of the applied electric field to the gas pressure for Argon–Hydrogen mixture.

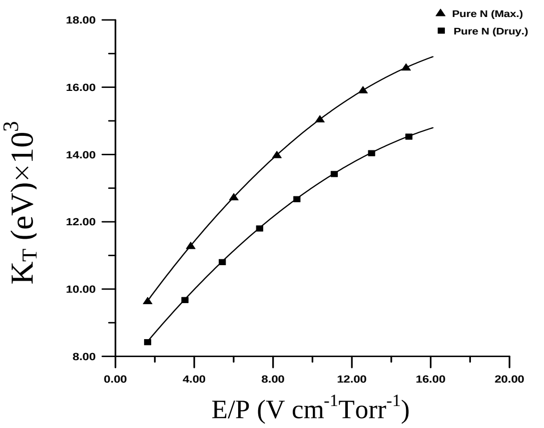

Fig. (2): The Townsend's energy factors as a function of the ratio of the applied electric field to the gas pressure for pure Nitrogen.

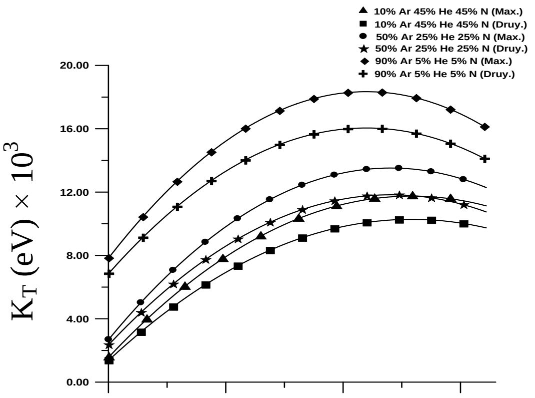

Fig. (3): The Townsend's energy factors as a function of the ratio of the applied electric field to the gas pressure for Argon–Helium- Nitrogen

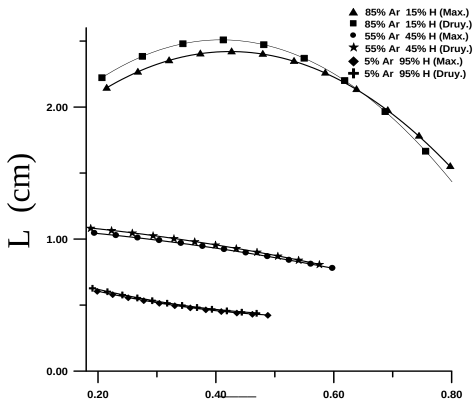

Fig. (4): The mean free path at unit pressure (L) versus mean velocity of agitation $\overline{U}$ for Argon–Hydrogen mixture.

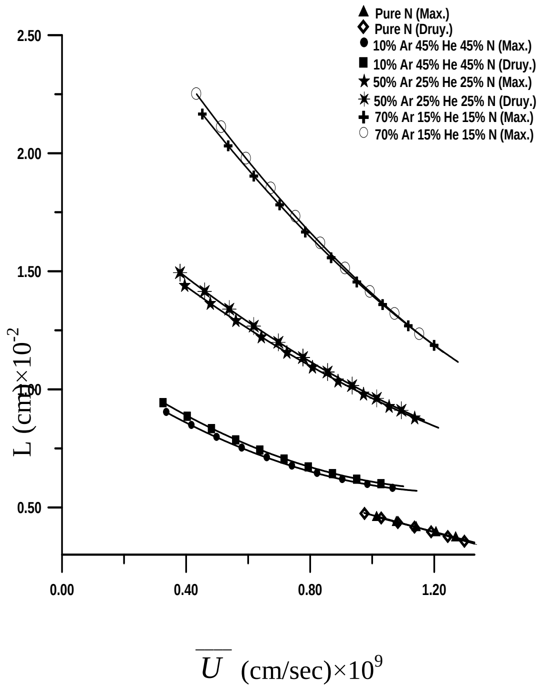

Fig. (5): The mean free path at unit pressure (L) versus mean velocity of agitation $\overline{U}$ for Pure Nitrogen and Argon–Helium - Nitrogen mixture.

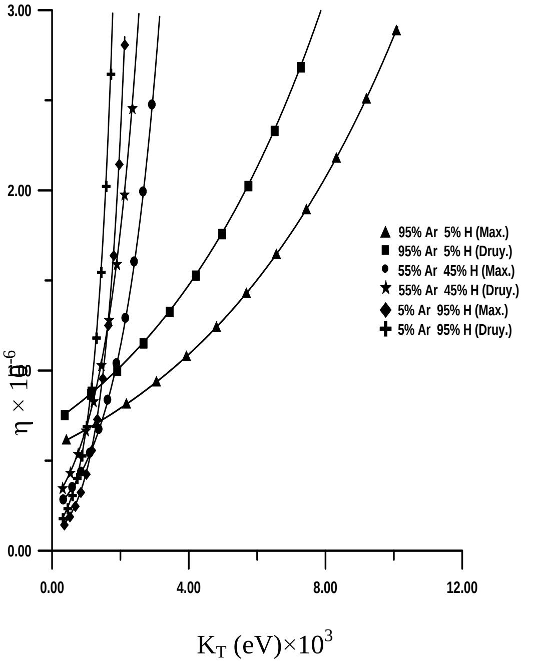

Fig. (6): The mean proportion of energy lost by an electron per collision (η) as a function of the Townsend's energy factor (K_T) for Argon–Hydrogen mixture.

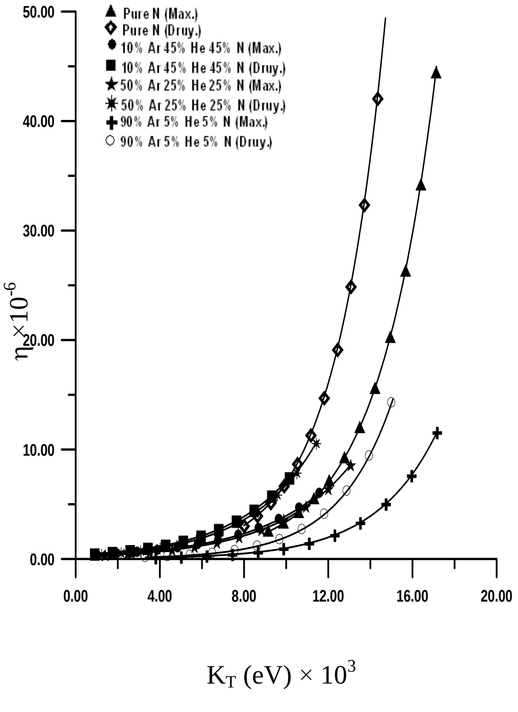

Fig.(7): The mean proportion of energy lost by an electron per collision (η) plotted as a function of the Townsend's energy factor (K_T) for pure Nitrogen and Argon–Helium–Nitrogen.

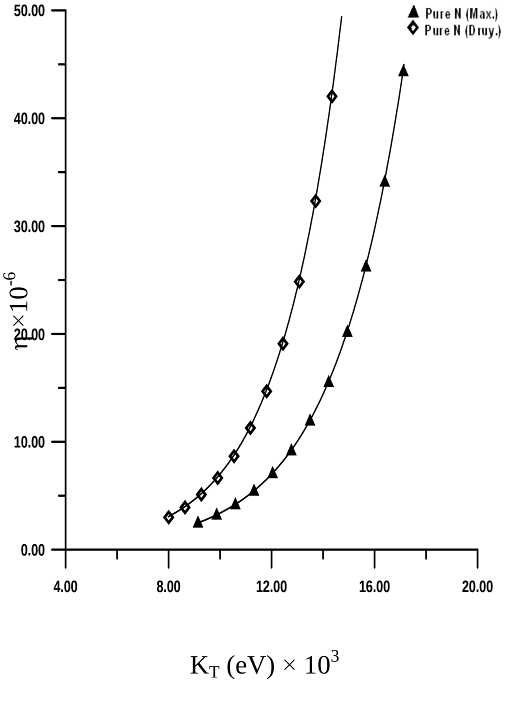

Fig. (8): The mean proportion of energy lost by an electron per collision (η) plotted as a function of the Townsend's energy factor (K_T) for pure Nitrogen and Argon–Helium–Nitrogen.

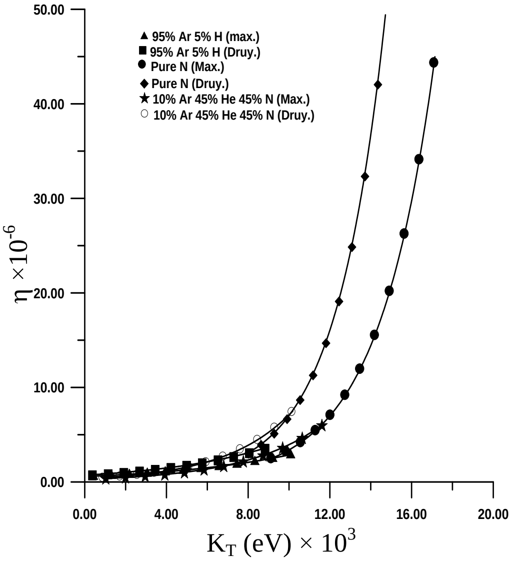

Fig. (9): The mean proportion of energy lost by an electron per collision (η) as a function of the Townsend's energy factor (K_T) for Argon–Hydrogen mixture, pure Nitrogen and Argon–Helium–Nitrogen mixture.

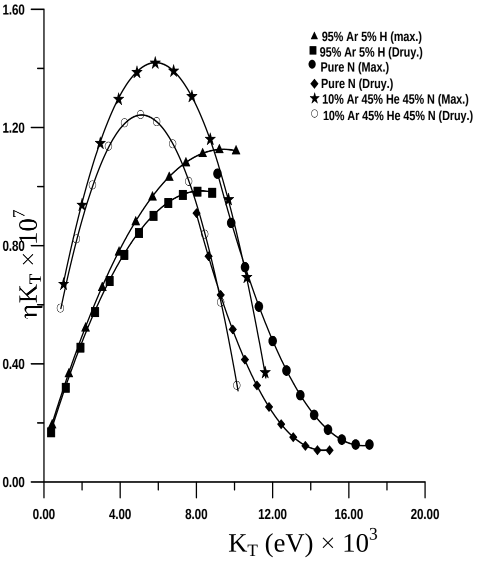

Fig. (10): The mean energy lost by an electron per collision (ηK_T) as a function of the Townsend's energy factor (K_T) for Argon–Hydrogen mixture, pure Nitrogen and Argon – Helium – Nitrogen mixture.

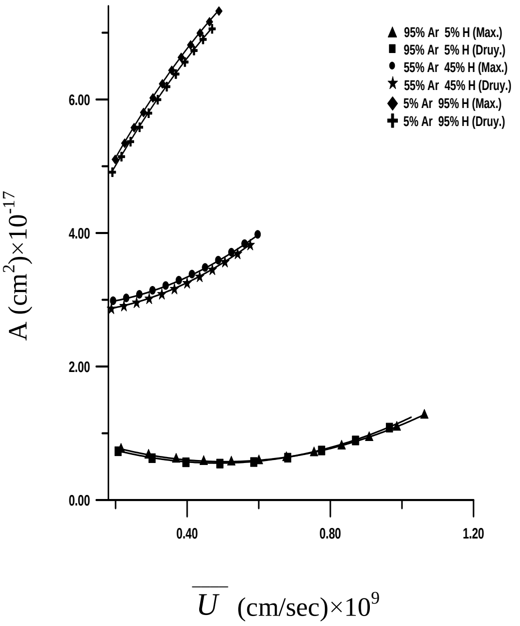

Fig. (11): Gas kinetic cross–section for electrons as a function of the mean velocity of agitation $\overline{U}$ for Argon–Hydrogen mixture.

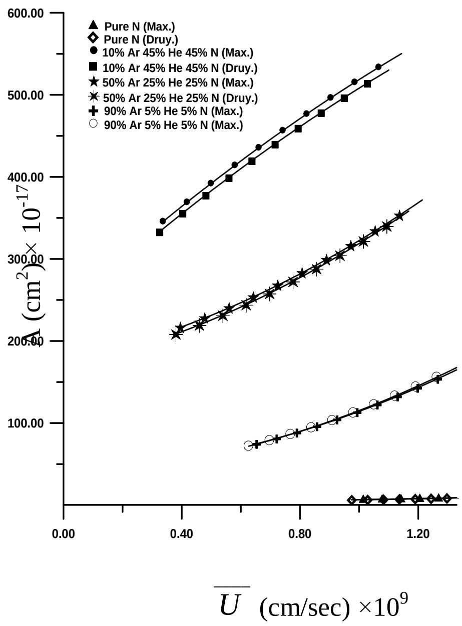

Fig. (12): Gas kinetic cross – section for electrons as a function of the mean velocity of agitation $\overline{U}$.

Appendix

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 Dimension ep(11),e(11),vd(11),du(11),vm(11),vu(11),ak1(11),aktm(11
   1),aktd(11),um(11),ud(11),alm(11),ald(11),etam(11),etad(11),g(11)
   2,etakm(11),etakd(11),am(11),ad(11),vdd(11)
        ee =1.602e-19
        ak=1.38e-23
        om=9.109e-28
        tg=300
    Open(5,FILE='e:\fortran\1a.DAT')
    open(8,FILE='e:\fortran\1out.DAT')
        do 2 i=1,11
        read(5,1)ep(i),e(i),vd(i),du(i),vm(i),vu(i)
 1   format(e10.4,e12.6,e11.5,e9.3,e10.4,e12.6)
        ak1(I)=(ee/ak)*du(i)
        vdd(i)=38.7*e(i)/ak1(i)
        aktm(i)=ak1(i)
        aktd(i)=0.875*ak1(i)
        um(i)=1.06e+07*ak1(i)**0.5
        ud(i)=1.02e+07*ak1(i)**0.5
        alm(i)=7.11e-09*((vd(i)*ak1(i)**0.5)/ep(i))
        ald(i)=7.38e-09*((vd(i)*ak1(i)**0.5)/ep(i))
        etam(i)=1.79e-14*vd(i)**2/ak1(i)
        etad(i)=2.21e-14*vd(i)**2/ak1(i)
        g(i)=vm(i)/vu(i)
        etakm(i)=g(i)*(ak1(i)-1)
        etakd(i)=g(i)*(0.875*ak1(i)-1)
        am(i)=1/(3.22e+16*7.11e-09*(vd(i)*ak1(i)**.5/ep(i)))
 2      ad(i)=1/(3.22e+16*7.38e-09*(vd(i)*ak1(i)**.5/ep(i)))
    write(8,*)'Table(1): The calculated electron diffusion motion parameters'
        write(8,*)'         for Argon(95%) - Hydrogen(5%) mixture in according to
Maxwell law'
        write(8,3)
 3   format(2x,'E/P',8x,'Vd',9x,'K1',8x,'L',9x,'U',8x,'Eta',6x,
   1'EtaKt',7x,'A',7x,'Vd/D')
    do 4 i=1,11
 4   write(8,5)ep(i),vd(i),ak1(i),alm(i),um(i),etam(i),etakm(i),am(i),
   1vdd(i)
 5      format(9(e9.4,1x))
    write(8,*)'Table(2): The calculated electron diffusion motion parameters'
        write(8,*)'         for Argon(95%) - Hydrogen(5%) mixture in according to
Druyvesteyn law'
        write(8,6)
 6   format(2x,'E/P',8x,'Vd',9x,'Kt',8x,'L',9x,'U',8x,'Eta',6x,
   1'EtaKt',7x,'A',7x,'Vd/D')
    do 7 i=1,11
 7   write(8,8)ep(i),vd(i),aktd(i),ald(i),ud(i),etad(i),etakd(i),ad(i),
   1vdd(i)
 8      format(9(e9.4,1x))
        stop
    end
```

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الواجهات التطبيقية لانتشار الإلكترونات الواطئة الطاقة في غازات طبقات الجو

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الخلاصة:

تم في هذا العمل حساب انتشار الإلكترونات واطئة الطاقة في غازات طبقات الجو، مثلاً (مزيج من غاز الآركون – الهيدروجين، غاز النيتروجين ومزيج من غاز الآركون – الهيليوم – النيتروجين) بوجود المجال الكهربائي وعند درجة حرارة 300 كلفن. قادت هذه الحسابات الى إيجاد قيمة طاقة تاون سيند بوصفها دالة لـ E/P (شدة المجال الكهربائي / ضغط الغاز)، شدة المجال الكهربائي، سرعة جرف الإلكترونات، تردد التصادم لانتقال الزخم، تردد التصادم لتبادل الطاقة والطاقة المميزة.

تم اشتقاق الكميات الفيزياوية التي تم حسابها بوصفها دالة لـ E/P والتي تمثل أهم المعلمات الأساسية في دراسة غازات طبقات الجو وهي: معدل المسار الحر للإلكترونات بوحدة الضغط، معدل الطاقة المفقودة للإلكترون لكل تصادم، معدل سرعة التوهج والمقاطع العرضية التصادمية لجزيئات الوسط. هذه النتائج تم عرضها على شكل جداول وأشكال، إذ أظهرت تطابقاً مع النتائج العملية المنشورة.