Theoretical Calculations of the Electron Transport Parameters in CH_4-Ar and CH_4-Ne Mixtures Gases Using Monte Carlo Method

Enas Ahmed Jawad
Dept. of Physics /College of Education For Pure Science (Ibn Al-Haitham)/
University of Baghdad

Received in:5/June/2016 ، Accepted in:12/December/2016

Abstract

The result of concentration varying of mixture methane with argon and neon gas are believed to study the change in electrons energy distribution function and then the change of the electrons transport parameters including the drift velocity, the mean energy, characteristics energy and diffusion coefficient. In the present work,a contemporary developed computer, simulation program known as Bolsig$^+$ is being used for calculating the electron transport parameters.

Key words: Boltzmann equation, CH_4 - Ar,CH_4 -Ne gas mixtures, Plasma and Electron Discharges, drift velocity, diffusion coefficient, transport parameters, distribution function .

Introduction

The electron transport parameters of pure and mixtures gas were studied for a wide range of applied electric field. These parameters which include the drift mobility, velocity, diffusion coefficient, ionization coefficient and mean electron energy, that are described in collision cross section and the electron energy distribution function (EEDF) represented the backbone of the electron swarm conduct of pure and mixtures gas in discharge of plasma [1,2].

The solution of Boltzmann equation is generally found by utilizing the Lorenz approximation in which the initial two terms of the spherical harmonic development are considered. The numerical solution of the Boltzmann equation yields the electron energy distribution with the electric field E and gas number density N as parameters. Convenient integration of the energy distribution function yields the transport and ionizing properties of the electron swarm.

The electron transport in a gas under the have an effect of an electric field E can be simulated with the assist of a Monte Carlo method [3-8]. Each electron, during its transit in the gas, performs a succession of free flights punctuated through elastic or inelastic collisions with molecules of gas defined by collision cross sections. Throughout the successive collisions for each electron, certain facts (velocity, position, and many others.) is saved to be able to calculate.

In this paper, we have studied the conduct of electrons in uniform electric fields by a Monte Carlo method. Swarm parameters are determined as a function of E/N for various rates of increase of the electric field [9].

The aim of this work is to study theoretically the electron energy distribution function and electron transport parameters in DC electric discharge processes in methane, Argon and Neon gases and their mixtures to various proportions from Monte Carlo simulation program.

2. Theory

2.1. Boltzmann equation

The transport Boltzmann equation governing the electron distribution fundamental function; this equation can be driven simply by defining a distribution function and inspecting its time derivative.

From this equation numerous important swarm parameters could be determined that it is as yet being utilized as a part of numerous contemporary research projects to model transport phenomena. The Boltzmann equation for electrons in an ionized gas is[10,11].

$$\left(\left(\frac{\partial}{\partial t}\right) + v\,.\nabla_{\mathrm{r}} + \left(\frac{eE}{m}\right)\,.\nabla_{v}\right) f(\mathrm{r},v,t) = \left(\frac{\partial f}{\partial t}\right)_{collisions}, \quad \ldots\ldots\ldots\ldots\ldots(1)$$

or

$$\left(\frac{\partial f}{\partial t}\right) + v\,.\nabla_{\mathrm{r}} f + \mathrm{a}\,.\nabla_{v} f = \Sigma \iint [f(v',r,t)F_j(V_j',r,t) - f(\mathrm{r},v,t)F_j(V_j,r,t) * v_{rj}\sigma_j(\theta,v_{rj})d\Omega_j dV_j$$

where , $f(r\,,v,t)$ is the electrons distribution function, a is the acceleration of charges particles and v is the velocity of charge particles.

$F_j\,(\mathrm{V}_j\,,r\,,t)$ is the neutral species distribution function.
V_j is the velocity of neutral species.
$v_{rj} = \left|v - V_j\right|$ is the relative velocity of charges particles

$\sigma_j(\theta, v_{rj})$ is the differential microscopic cross section of interaction the charges particles (electron) with neutral gas species j.
$d\boldsymbol{\Omega}_j = \sin d\theta\, d$ is the element solid angle, where θ and $\boldsymbol{\phi}$ are the polar and azimuthally angles, respectively.

The electron distribution function can be written by utilizing the two-term approximation extension as follows [12]:

$$f(r, v, t) = f + \sum_{l=0}^{\infty} f_l\,(r, v, t) p_l(\cos\theta) \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

2.2 Transport parameters

The swarm parameters of electrons and collision cross-sections with molecules are identified with each other through the medium of the velocity distribution function of the swarm.
The electron mean energy is,[13 and 14]

$$\varepsilon = \frac{2}{3}\int_0^{\infty} u^{3/2} f_o(u, E/N, T)\,du \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where(ε) is expressed in electron volts.

The drift velocity Vd, is [15]

$$\mathrm{V_d} = -\left(\frac{2e}{m}\right)^{1/2}\left(\frac{E/N}{3}\right)\int_0^{\infty} \frac{u}{\sum \delta_S Q_{sm}(u)}\frac{df_o}{du}\,du \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where u is the electron energy in (eV), δ_S is the number density of molecules (N_s)of species S divided by gas number density N ($\delta_s = \frac{N_S}{N}$), whereQ_m is momentum transfer cross section (cm^{-2}), the mobility is defined as the proportionally coefficient between the drift velocity of charged particle and electric field . The mobility of electrons is:

$$\mu_e = \frac{e}{m\,v_m} = \frac{v_d}{E} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

where $v_m$represents the electron momentum- transfer collision frequency.

From the connection between the drift velocity and mobility, we can compute electron mobility equation [16]:

$$\boldsymbol{\mu_e = -\frac{1}{3}\frac{2e}{m}\int_0^{\infty}\frac{u^{3/2}}{v_m(u)}\frac{\partial f_0}{\partial u}du} \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

The connection between diffusion coefficient and electron energy distribution function is given by[17]:

$$\boldsymbol{D_e = \frac{1}{3}\frac{2}{m}\int_0^{\infty}\frac{u^{3/2}}{v_m(u)}f_0 du} \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Characteristics energy (eV) is given by relation:

$$\boldsymbol{u_{ch} = e\,\frac{D_e}{\mu_e}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Result and Discussion

To calculate the drift velocity of electrons and the others transport parameters utilizing the Monte Carlo simulation program, knowledge of the reliance of the momentum transfer cross section on the electron energy is basis. The drift velocity does not rely on upon electron energy distribution function significantly, especially when the cross section does not fluctuate quickly with electron energy.

We present the results of several transport parameters for various mixtures of methane in argon and neon. For range of E/N values (1 Td ≤E/N≤800 Td) the diverse ratios mixtures of (CH_4 – Ar) and (CH_4 – Ne) gases are recorded in Table (1-8).

Tables (1 and 2) clarify the computed results for the drift velocity V_d as a function of E/N , in (CH_4 – Ar) and (CH_4 – Ne) gases, respectively.

Tables (3 and 4) explain the computed results for the electron mean energy, in different ratios of gas mixtures (CH_4 – Ar) and (CH_4 – Ne) gases, respectively.

Tables (5 and 6) clarify the calculated results for the electron characteristics energy, in different ratios of gas mixtures (CH_4 – Ar) and (CH_4 – Ne) gases, respectively .

Tables (7and 8) explain the computed results for the diffusion coefficient ,in various proportions of gas mixtures (CH_4 – Ar) and (CH_4 – Ne)gases , respectively.

Figures (1-3) exhibit the cross sections for electron of methane, argon and neon as a function of electron energy.

The impact of different discharge parameters on the electron distribution function is appeared in figures 4 and 5 for (CH_4 – Ar) and (CH_4 – Ne)gases, respectively. The electron energy distribution function is strongly influenced by changing either the parameter E/N or gas mixtures.

Figures (6 -9) clarify the assortment for the mean electron energy and characteristics energy vs. (E/N) in pure methane and mixture with argon and neon gas by taking into consideration various proportion mixing ratios.

Figures (10 and 11) show the diffusion coefficient for different ratios of mixtures methane with argon and neon gas. As a function of E/N in different ratios of gas mixture (CH_4 – Ar) and (CH_4 – Ne) respectively.

The drift velocity of electrons in various mixtures of (CH_4 – Ar) and (CH_4 – Ne) gases are appeared in figures12 and 13 as a function of E/N. It's necessary to note that there are measured experimentally published results that plotted with present work in the aforesaid two figures for comparison as shown in figures 14 and 15 for gases mixture (CH_4 – Ar) and (CH_4 – Ne) respectively . The results demonstrate a good agreement with the experimental values [18-20].

Conclusion

In this study, we have analyzed the conduct of electrons in uniform electric fields using a Monte Carlo simulation. The calculating electron energy distribution function for (CH_4 – Ar) and (CH_4 – Ne) mixtures with various concentrations has been described.

The conduct of the swarm parameters, which are drift velocity and mean kinetic electron energy rely on the proportion of the mixture components, can likely, be demonstrated by a preferential weighting of the elastic and inelastic scattering of the electrons on methane with argon and neon molecules at various estimations of E\N, additionally the results were in great concurrence with the computational work.

Reference

1. Date, H. and Sakai, H., (1989),"Boltzmann Equation analysis of electron collision cross section and swarm parameters for krypton", J. phys. D: Appl. Phys.,.22,.1478-1481.

2. Dahl Dominik, A .; Teich Timm, H . and Christian Franck M .,(2012), "Obtaining precise electron swarm parameters from a pulsed Townsend setup", J.Phys. D: Appl. Phys. **45,**485201 (9).

3. Grapperhaus, M . J. and Kushner, M .J. (1997), "A Semi-analytic Radio Frequency S heath Model Integrated into a two dimensional Hybrid Model for Plasma Processing Reactors", J. Appl. Phys.81(2): 569-577.

4. Tessarotto, M ., White R. B. and J. ZhengL, (1994), Monte Carlo approach to Collisional Transport, Phys. Plasmas 1(8): 2603-2613.

5. Ardehali ,M. (1994).,"Monte Carlo Simulation of Ion Transport through Radio Frequency" Collisional S heathsJ, Vac. Sci. TechnolA. .12(6):3242-3244.

6. Helin ,W., Zuli, L. and Daming, L. (1996). "Monte Carlo Simulation for Electron Neutral Collision Processes in Normal and Abnormal Discharge Cathode S heath Region", Vacuum 47(9)r:0 6s-1072.

7. Stache, J. (1994)."Hybrid Modeling of Deposition Profiles in Magnetron Sputtering Systems" , J. Vac. Sci.Technol A.l2(5);2867-2873.

8. Nathan, S. S., Rao G. M. and Mohan, S. , (1998)."Transport of Sputtered A toms in Facing Targets Sputtering Geometry": A Numerical Simulation Study, J. Appl. Phys.8a(l): 564-571.

9. Rabie, M, Haefliger P, Chachereau A and Franck C M, (2015), "Obtaining electron attachment cross sections by means of linear inversion of swarm parameters", J. Phys. D: Appl. Phys. 48 ,075201 (7).

10. Edward, A. and Eral Mc Daniel, W., (1988), "Transport properties of ions in gases", John Wiely and Sons, Inc.

11. Morgan W.L. and Penetrane B.M., (1990), Computer physics communication CPC,.58,. 127-152.

12. Smith K. and Thomson R. W., (1978), " Computer Modeling of Gas", Plenum Press, New York.

13.Wang Y. &Olthoff J.K., (1999), "Ion energy distributions in inductively coupled radio-frequency discharges in argon, nitrogen, oxygen, chlorine, and their mixtures" , Journal of Applied Physics,.85, 6358-6365.

14. Kondo1 Y., Sekiya2 Y., M. Th. EL-Mohandes3, (2013) "Pulse Townsend Measurement of Electron Swarm Parameters at Low Pressure " International Journal of Emerging Technology and Advanced (ISSN 2250-2459, ISO 9001:(2008) Certified Journal, Volume 3, Issue 11.

15. Morgan W.L,(2002)."Electron collision cross sections for tetraethoxy silane", Journal of Applied Physics,. 92,. 1663-1667.

16. Truesdell C., Chem J.. Phys, 37, 2336,(1962).

17. Makabe T. and Petrovic Z., 2006. "Plasma Electronics: Application in Micro- Electronics Device Fabrication" , Taylor and Francis Group, New York,

18.Piuz F., Nucl. Instrum .Meth. vol. 205, pp. 425-436, (1983).

19. D. K. Davies, L. E. Kline, and W. E. Bies, (1989*)*,J. Appl. Phys.. 65,. 3311-23.

20. Mathieson E. and Hakeem N El 1979." Calculation of electron transport coefficients in counting gas mixtures" Nucl. Instr. Meth. 159, 489.

Table (1) The data of Drift velocity V_d (cm/s) of electron as a function E/N in different ratio CH_4-Ar mixtures.

Electric field/gas density E/N (Td=10^{-17} V.cm^2)	V_d $\times10^6$ pure CH_4	$V_d\times10^6$ CH_4–Ar (10/90)%	$V_d\times10^6$ CH_4–Ar (20/80)%	$V_d\times10^6$ CH_4–Ar (30/70)%	$V_d\times10^6$ CH_4–Ar (40/60)%	$V_d\times10^6$ CH_4–Ar (50/50)%	$V_d\times10^6$ CH_4–Ar (60/40)%	$V_d\times10^6$ CH_4–Ar (70/30)%	$V_d\times10^6$ CH_4–Ar (80/20)%	$V_d\times10^6$ CH_4–Ar (90/10)%
1	4.72	4.41	6.92	7.32	7.52	7.30	6.86	6.31	5.75	5.21
2	4.72	3.27	5.24	6.74	7.86	8.65	9.21	9.47	5.75	5.21
4	1.01	2.39	3.79	4.97	6.02	6.95	7.77	8.49	9.12	9.68
8	7.76	1.85	2.75	3.50	4.17	4.79	5.36	5.91	6.43	7.27
10	6.87	1.86	2.66	3.35	4.23	4.50	5.06	5.51	5.99	6.44
20	4.82	2.30	2.69	3.02	4.32	3.60	3.87	4.12	4.37	4.59
40	4.85	3.75	4.03	4.25	4.41	4.53	4.62	4.69	4.74	4.81
80	7.80	6.63	6.89	7.12	7.31	7.46	7.58	7.67	7.73	7.78
100	9.44	8.07	8.33	8.57	8.78	8.96	9.11	9.23	9.32	9.38
200	1.79	15.3	15.6	15.9	16.2	16.6	16.8	17.1	17.3	17.0
400	35.4	23.1	164	119	91.3	73.0	60.4	51.4	44.7	39.5
800	72.2	42.4	130	136	127	116	106	95.6	86.8	79.0

Table (2) The data of Drift velocity V_d (cm/s) of electron as a function E/N in different ratio CH_4-Ne mixtures.

Electric field/gas density E/N (Td=10^{-17} V.cm^2)	V_d $\times10^6$ pure CH_4	$V_d\times10^6$ CH_4–Ne (10/90)%	$V_d\times10^6$ CH_4–Ne (20/80)%	$V_d\times10^6$ CH_4–Ne (30/70)%	$V_d\times10^6$ CH_4–Ne (40/60)%	$V_d\times10^6$ CH_4–Ne (50/50)%	$V_d\times10^6$ CH_4–Ne (60/40)%	$V_d\times10^6$ CH_4–Ne (70/30)%	$V_d\times10^6$ CH_4–Ne (80/20)%	$V_d\times10^6$ CH_4–Ne (90/10)%
1	4.72	3.23	4.23	4.81	5.14	5.30	5.33	5.26	5.12	4.93
2	4.72	3.17	4.56	5.61	6.44	7.13	7.70	8.19	8.61	4.93
4	1.01	2.84	3.90	4.88	5.78	6.60	7.33	8.11	8.80	9.48
8	7.76	3.41	3.53	3.98	4.52	5.08	5.63	6.18	6.71	7.20
10	6.87	3.92	3.69	3.85	4.22	4.65	5.09	5.54	5.99	6.43
20	4.82	6.64	5.63	4.95	4.53	4.32	4.27	4.33	4.46	4.63
40	4.85	11.8	9.96	8.52	7.46	6.67	6.08	5.64	5.28	5.03
80	7.80	20.7	18.0	15.6	1.36	12.1	10.8	9.89	9.03	8.36
100	9.44	24.8	21.8	19.0	16.7	14.8	13.3	12.0	11.0	10.2
200	1.79	42.6	39.0	34.9	31.2	28.0	25.2	22.9	21.0	19.3
400	35.4	71.1	69.1	64.5	59.3	54.1	49.4	45.2	41.5	38.3
800	72.2	80.3	90	94.0	94.4	92.6	89.4	85.9	81.1	76.6

Table (3) The data of the mean electron Energy (eV) as a function E/N in different ratio CH_4 – Ar mixtures.

Electric field/gas density E/N (Td=10^{-17} V.cm^2)	ε(eV) pure CH_4	ε(eV) CH_4–Ar (10/90)%	ε(eV) CH_4–Ar (20/80)%	ε(eV) CH_4–Ar (30/70)%	ε(eV) CH_4–Ar (40/60)%	ε(eV) CH_4–Ar (50/50)%	ε(eV) CH_4–Ar (60/40)%	ε(eV) CH_4–Ar (70/30)%	ε(eV) CH_4–Ar (80/20)%	ε(eV) CH_4–Ar (90/10)%
1	0.11	0.59	0.39	0.31	0.26	0.22	0.19	0.16	0.14	0.12
2	0.26	0.95	0.69	0.57	0.49	0.43	0.39	0.35	0.32	0.28
4	0.51	1.69	1.21	0.99	0.85	0.76	0.69	0.63	0.59	0.54
8	0.88	2.96	2.2	1.78	1.52	1.34	1.21	1.1	1.02	0.93
10	1.05	3.36	2.58	2.1	1.79	1.57	1.41	1.29	1.19	1.11
20	1.87	4.49	3.96	3.55	3.19	2.87	2.6	2.36	2.17	2.01
40	3.29	5.29	4.89	4.6	4.37	4.16	3.97	3.8	3.63	3.45
80	4.43	6.01	5.75	5.49	5.28	5.1	4.94	4.8	4.67	4.55
100	4.76	6.38	6.06	5.81	5.6	5.41	5.26	5.12	4.99	4.87
200	5.99	7.49	7.25	7.03	6.84	6.66	6.5	6.36	6.23	6.1
400	8.11	19.71	15.63	13.33	11.84	10.79	10.01	9.4	8.89	8.47
800	13.33	27.81	24.56	22.03	20.11	18.5	17.14	15.99	14.98	14.1

Table (4) The data of the mean electron Energy (eV) as a function E/N in different ratio CH_4 – Ne mixtures.

Electric field/gas density E/N (Td=10^{-17} V.cm^2)	ε(eV) pure CH_4	ε(eV) CH_4–Ne (10/90)%	ε(eV) CH_4–Ne (20/80)%	ε(eV) CH_4–Ne (30/70)%	ε(eV) CH_4–Ne (40/60)%	ε(eV) CH_4–Ne (50/50)%	ε(eV) CH_4–Ne (60/40)%	ε(eV) CH_4–Ne (70/30)%	ε(eV) CH_4–Ne (80/20)%	ε(eV) CH_4–Ne (90/10)%
1	0.11	0.41	0.29	0.24	0.21	0.18	0.16	0.15	0.13	0.12
2	0.26	0.91	0.59	0.47	0.41	0.37	0.34	0.31	0.29	0.27
4	0.51	2.07	1.27	0.97	0.81	0.72	0.65	0.6	0.56	0.53
8	0.88	3.65	2.61	1.94	1.56	1.34	1.19	1.08	1	0.93
10	1.05	4.04	3.14	2.43	1.95	1.65	1.45	1.3	1.2	1.11
20	1.87	5.12	4.38	3.9	3.6	3.14	2.78	2.48	2.23	2.03
40	3.29	6.41	5.46	4.94	4.59	4.31	4.08	3.86	3.66	3.47
80	4.43	8.36	6.97	6.22	5.74	5.39	5.13	4.91	4.74	4.57
100	4.76	9.21	7.64	6.77	6.21	5.81	5.51	5.27	5.08	4.91
200	5.99	13.07	10.71	9.28	8.33	7.66	7.16	6.77	6.46	6.2
400	8.11	20.64	17.1	14.5	12.78	11.44	10.42	9.64	9.02	8.52
800	13.33	32.09	28.35	25.23	22.6	20.3	18.49	16.89	15.51	14.34

Table (5) The data of the characteristic energy of electron u_{ch} (eV) as a function E/N in different ratio CH_4 – Ar mixtures.

Electric field/gas density E/N ($Td=10^{-17}$ $V.cm^2$)	u_{ch} (eV) pure CH_4	u_{ch} (eV) CH_4–Ar (10/90)%	u_{ch} (eV) CH_4–Ar (20/80)%	u_{ch} (eV) CH_4–Ar (30/70)%	u_{ch} (eV) CH_4–Ar (40/60)%	u_{ch} (eV) CH_4–Ar (50/50)%	u_{ch} (eV) CH_4–Ar (60/40)%	u_{ch} (eV) CH_4–Ar (70/30)%	u_{ch} (eV) CH_4–Ar (80/20)%	u_{ch} (eV) CH_4–Ar (90/10)%
1	0.08	0.58	0.35	0.26	0.2	0.16	0.14	0.12	0.1	0.09
2	0.08	1.16	0.74	0.55	0.44	0.36	0.31	0.27	0.1	0.09
4	0.43	2.22	1.51	1.16	0.95	0.8	0.69	0.6	0.54	0.48
8	0.97	4.05	2.89	2.32	1.96	1.7	1.5	1.34	1.21	1.06
10	1.25	4.66	3.4	2.75	2.34	2.05	1.82	1.64	1.49	1.36
20	2.51	6.32	5.28	4.57	4.04	3.64	3.32	3.07	2.85	2.67
40	3.81	7.17	6.36	5.76	5.3	4.93	4.63	4.38	4.17	3.97
80	4.49	7.69	7.03	6.49	6.04	5.67	5.36	5.09	4.86	4.67
100	4.65	7.81	7.19	6.67	6.23	5.86	5.55	5.27	5.04	4.83
200	5.19	8.07	7.55	7.12	6.74	6.4	6.11	5.84	5.6	5.38
400	6.17	29.66	14.69	10.12	8.81	7.84	7.25	6.86	6.58	6.36
800	10.87	55.733	75.51	41.29	28.7	22.14	18.12	15.4	13.45	11.99

Table (6) The data of the characteristic energy of electron u_{ch} (eV) as a function E/N in different ratio CH_4 – Ne mixtures.

Electric field/gas density E/N ($Td=10^{-17}$ $V.cm^2$)	u_{ch} (eV) pure CH_4	u_{ch} (eV) CH_4–Ne (10/90) %	u_{ch} (eV) CH_4–Ne (20/80)%	u_{ch} (eV) CH_4–Ne (30/70)%	u_{ch} (eV) CH_4–Ne (40/60)%	u_{ch} (eV) CH_4–Ne (50/50)%	u_{ch} (eV) CH_4–Ne (60/40)%	u_{ch} (eV) CH_4–Ne (70/30)%	u_{ch} (eV) CH_4–Ne (80/20)%	u_{ch} (eV) CH_4–Ne (90/10)%
1	0.08	0.3	0.21	0.17	0.14	0.12	0.11	0.1	0.09	0.09
2	0.08	0.68	0.44	0.35	0.3	0.26	0.24	0.22	0.21	0.09
4	0.43	1.65	1.04	0.81	0.68	0.6	0.54	0.5	0.47	0.45
8	0.97	3.02	2.25	1.78	1.5	1.33	1.21	1.12	1.06	1.01
10	1.25	3.36	2.71	2.23	1.9	1.69	1.55	1.44	1.36	1.31
20	2.51	4.24	3.75	3.47	3.26	3.08	2.92	2.78	2.66	2.57
40	3.81	5.16	4.51	4.23	4.07	3.97	3.9	3.86	3.83	3.82
80	4.49	6.45	5.46	5.01	4.76	4.61	4.53	4.49	4.47	4.47
100	4.65	7	5.88	5.33	5.02	4.84	4.74	4.67	4.64	4.64
200	5.19	9.33	7.69	6.77	6.2	5.81	5.58	5.41	5.3	5.23
400	6.17	14.38	11.59	9.88	8.74	7.93	7.34	6.91	6.58	6.35
800	10.87	34.39	26.46	21.87	18.83	16.64	14.97	13.64	12.55	11.63

Table (7) The data of diffusion coefficient D_e (cm^2/s) of electron as a function E/N in different ratio CH_4 – Ar mixtures.

Electric field/gas density E/N (Td=10^{-17} V.cm^2)	$D_e\times10^3$ pure CH_4	$D_e\times10^3$ CH_4–Ar (10/90)%	$D_e\times10^3$ CH_4–Ar (20/80)%	$D_e\times10^3$ CH_4–Ar (30/70)%	$D_e\times10^3$ CH_4–Ar (40/60)%	$D_e\times10^3$ CH_4–Ar (50/50)%	$D_e\times10^3$ CH_4–Ar (60/40)%	$D_e\times10^3$ CH_4–Ar (70/30)%	$D_e\times10^3$ CH_4–Ar (80/20)%	$D_e\times10^3$ CH_4–Ar (90/10)%
1	1.42	9.46	8.43	6.99	5.64	4.48	3.54	2.80	2.22	1.77
2	1.42	7.05	7.25	6.92	6.42	5.86	5.25	4.69	2.22	1.77
4	4.08	4.93	5.32	5.38	5.31	5.16	4.97	4.77	4.55	4.31
8	3.52	3.48	3.70	3.78	3.80	3.79	3.75	3.70	3.63	3.60
10	3.21	3.22	3.37	3.43	3.44	3.43	3.40	3.37	3.32	3.27
20	2.25	2.72	2.64	2.56	2.50	2.44	2.39	2.35	2.32	2.28
40	1.72	2.50	2.39	2.28	2.17	2.08	1.99	1.91	1.84	1.78
80	1.63	2.37	2.25	2.15	2.05	1.97	1.89	1.82	1.75	1.69
100	1.63	2.35	2.23	2.13	3.04	1.95	1.88	1.81	1.74	1.69
200	1.73	2.30	2.19	2.10	2.03	1.96	1.91	1.85	1.81	1.77
400	2.04	63.9	22.4	11.8	7.48	5.33	9.08	3.28	2.73	2.34
800	3.65	115	45.8	26.1	17.0	12.4	8.90	6.85	5.43	4.41

Table (8) The data of diffusion coefficient D_e (cm^2/s) of electron as a function E/N in different ratio CH_4 – Ne mixtures.

Electric field/gas density E/N (Td=10^{-17} V.cm^2)	$D_e\times10^3$ pure CH_4	$D_e\times10^3$ CH_4–Ne (10/90)%	$D_e\times10^3$ CH_4–Ne (20/80)%	$D_e\times10^3$ CH_4–Ne (30/70)%	$D_e\times10^3$ CH_4–Ne (40/60)%	$D_e\times10^3$ CH_4–Ne (50/50)%	$D_e\times10^3$ CH_4–Ne (60/40)%	$D_e\times10^3$ CH_4–Ne (70/30)%	$D_e\times10^3$ CH_4–Ne (80/20)%	$D_e\times10^3$ CH_4–Ne (90/10)%
1	1.42	3.66	3.27	2.99	2.72	2.46	2.22	1.99	1.78	1.59
2	1.42	4.03	3.75	3.63	3.56	3.50	2.44	3.39	3.34	1.59
4	4.08	4.66	3.79	3.66	3.65	3.67	3.72	3.79	3.87	3.97
8	3.52	4.79	3.69	3.29	3.16	3.14	3.17	3.23	3.31	3.40
10	3.21	4.91	3.73	3.20	2.99	2.93	2.90	2.97	3.03	3.11
20	2.25	5.29	3.93	3.20	2.75	2.48	2.32	2.24	2.20	2.22
40	1.72	5.64	4.18	3.33	2.82	2.46	2.21	2.02	1.88	1.79
80	1.63	6.18	4.59	3.63	3.02	2.59	2.28	2.05	1.88	1.74
100	1.63	6.41	4.76	3.77	3.11	2.66	2.34	2.09	1.90	1.75
200	1.73	7.40	5.58	4.40	3.60	3.03	2.62	2.31	2.07	1.88
400	2.04	9.59	7.45	5.94	4.82	3.39	3.37	2.90	2.54	2.26
800	3.65	12.9	11.1	9.57	8.27	7.17	6.22	5.42	4.73	4.15

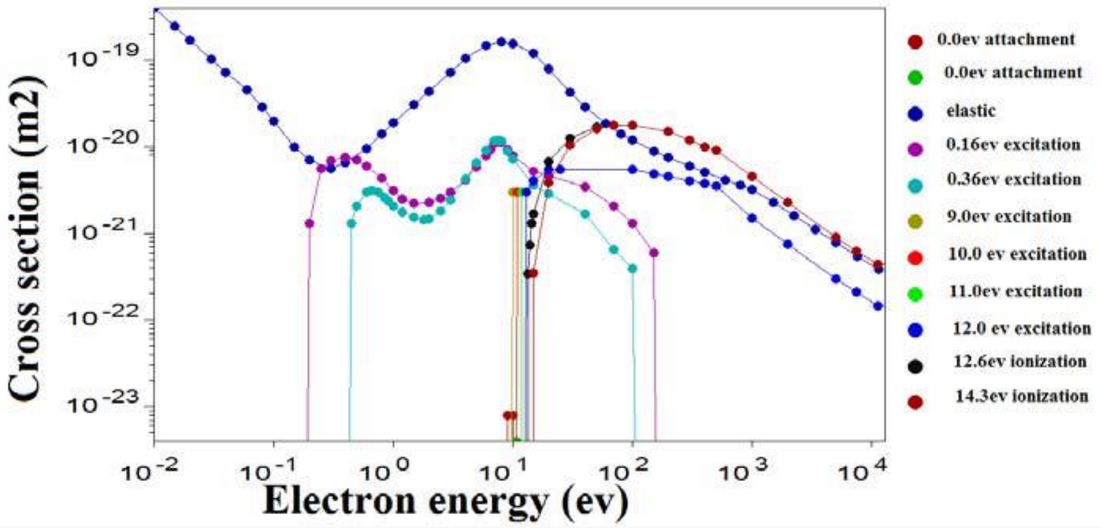

Figure (1) Elastic and inelastic cross section vs electron energy in CH_4.

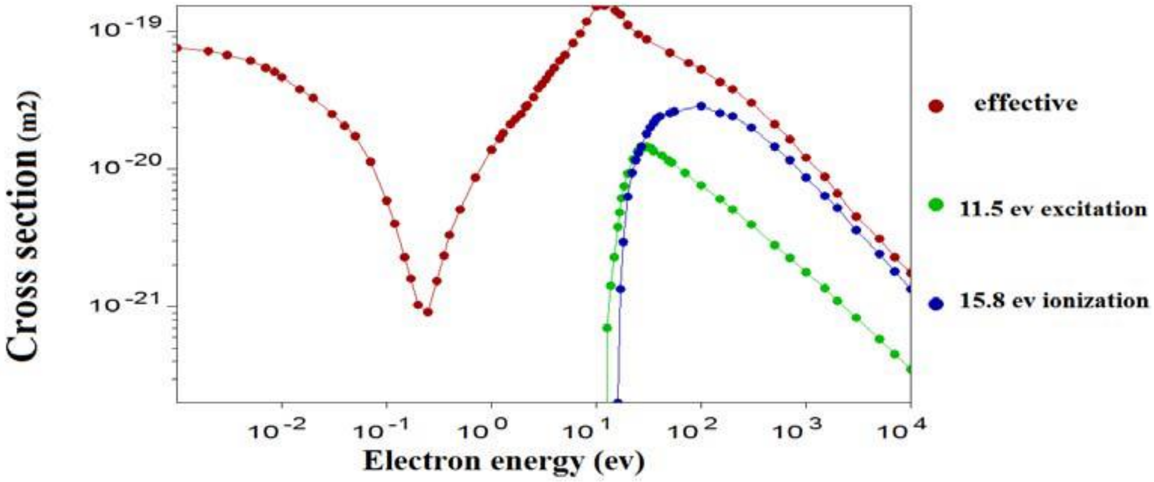

Figure (2) elastic and inelastic Cross section vs electron energy in Ar.

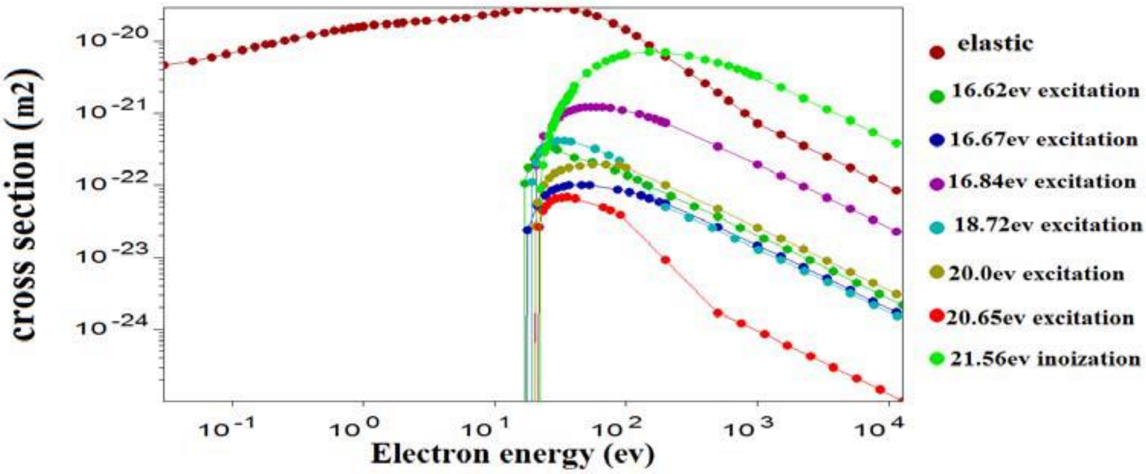

Figure (3) Elastic and inelastic Cross section vs electron energy in Ne

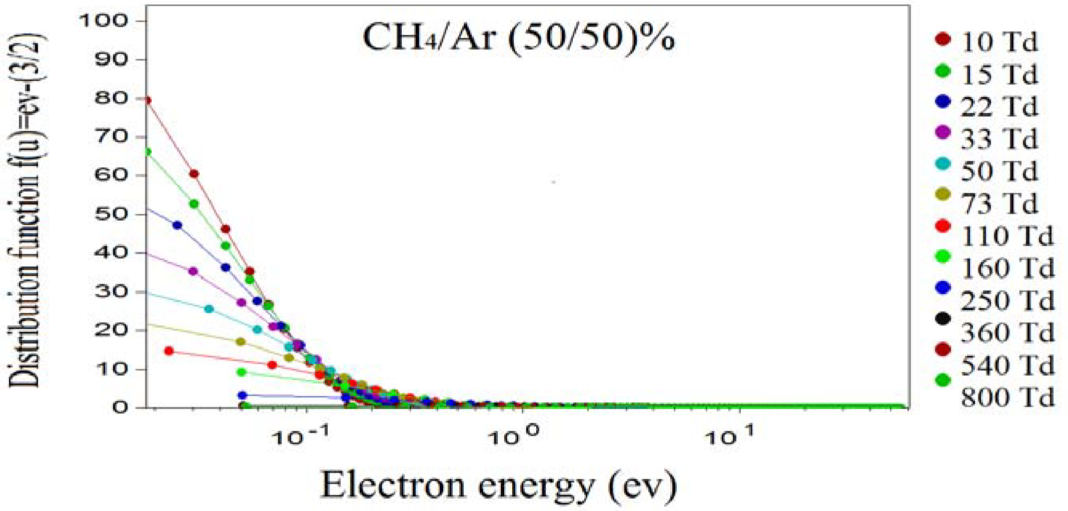

Figure (4) The electron energy distribution function versus the electron energy for CH_4-Ar(50/50%) gaseous mixture.

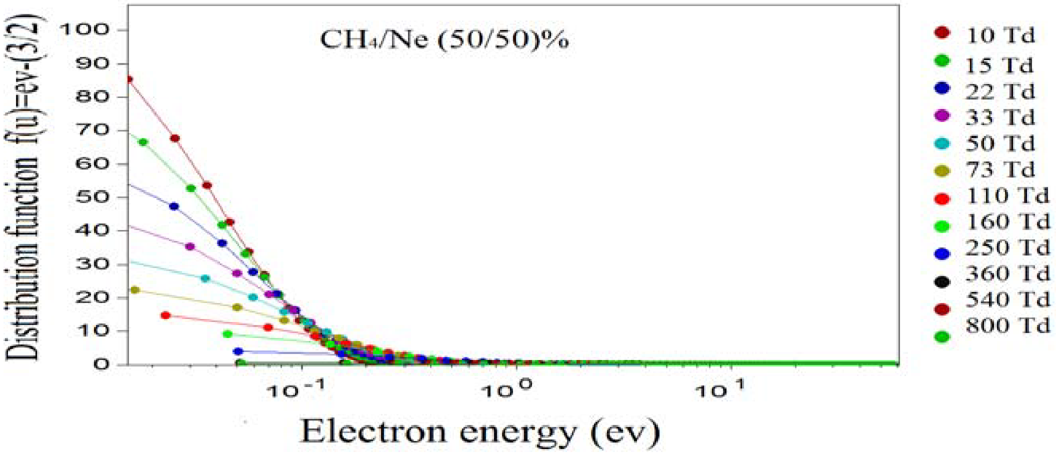

Figure (5) The electron energy distribution function versus the electron energy for CH_4-Ne(50/50%) gaseous mixture.

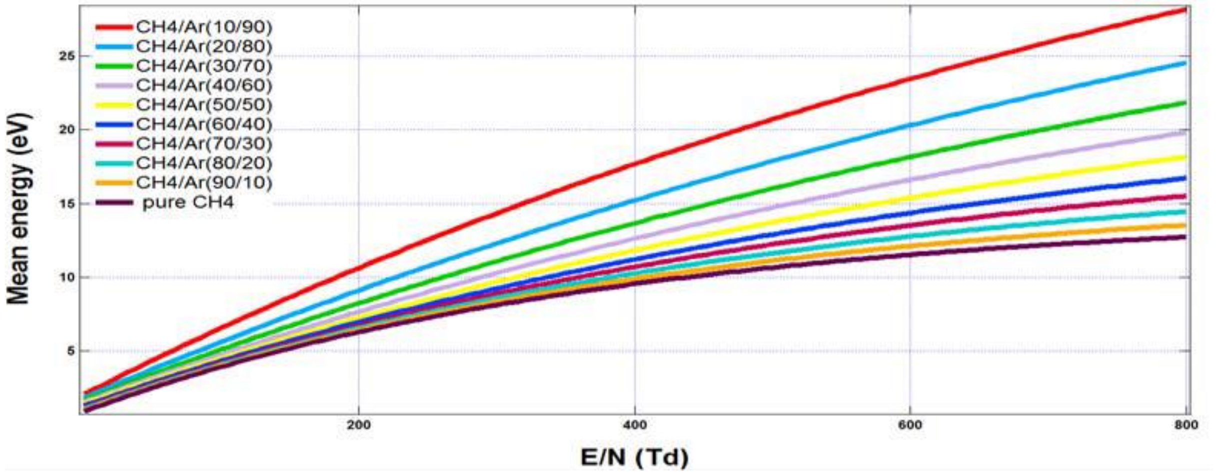

Figure (6) The mean electron energy as a function E/N in pure CH_4 and mixture with Ar .

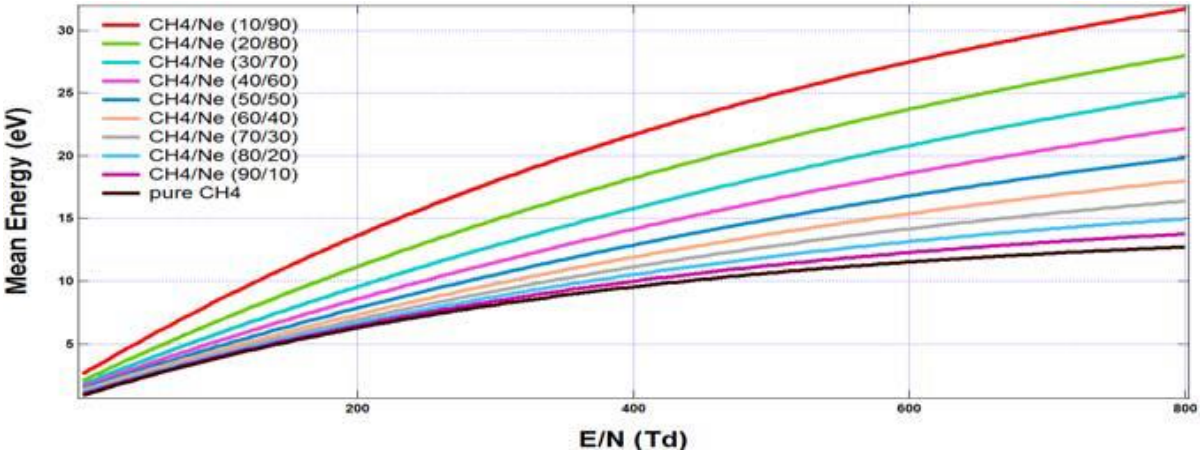

Figure (7) The mean electron energy as a function E/N in pure CH_4 and mixture with Ne.

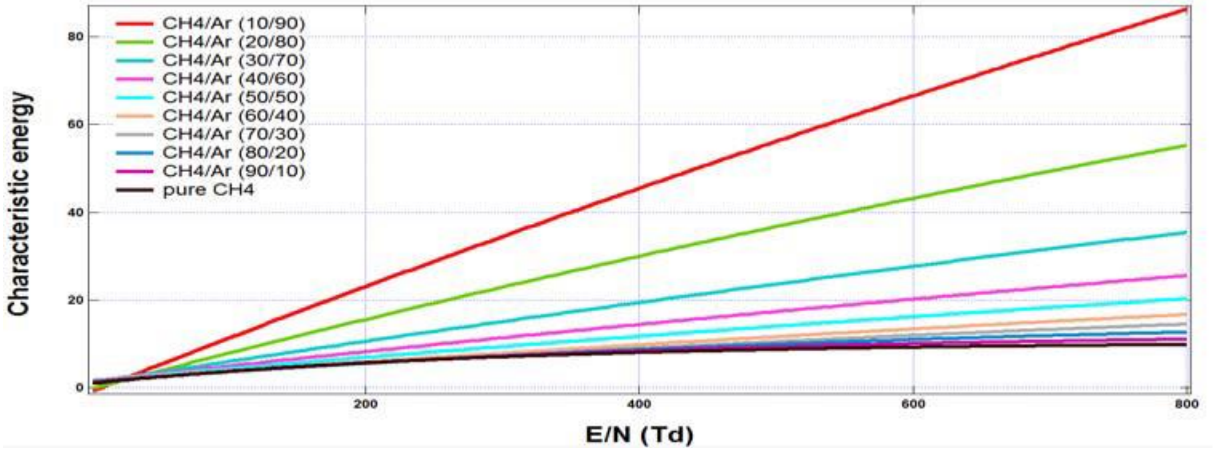

Figure (8) The characteristic electron energy as a function E/N in pure CH_4 and mixture with Ar .

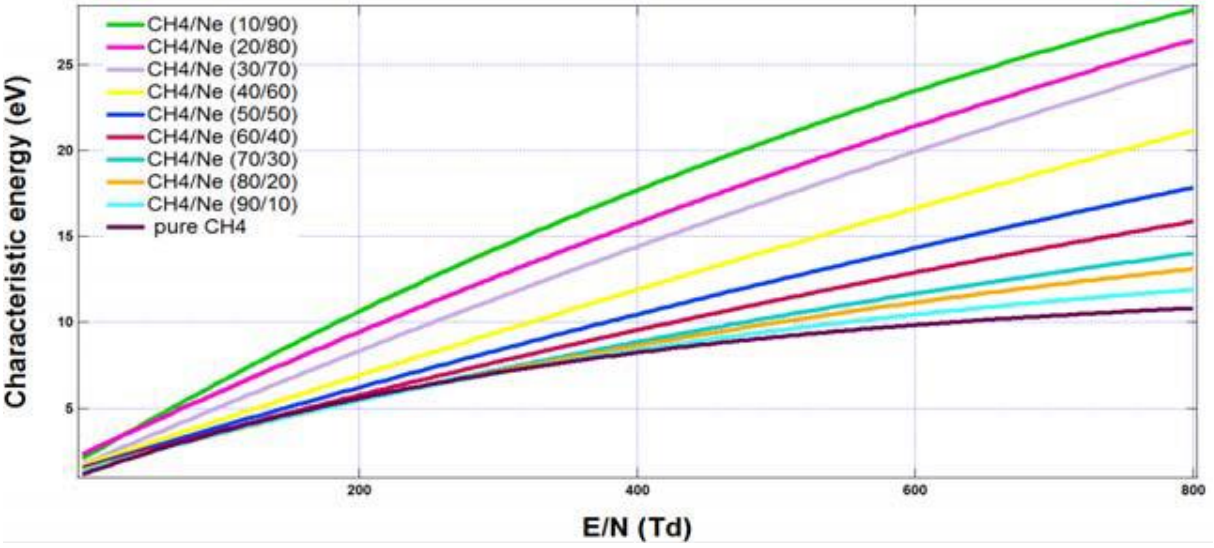

Figure (9) The characteristic electron energy as a function E/N in pure CH_4 and mixture with Ne .

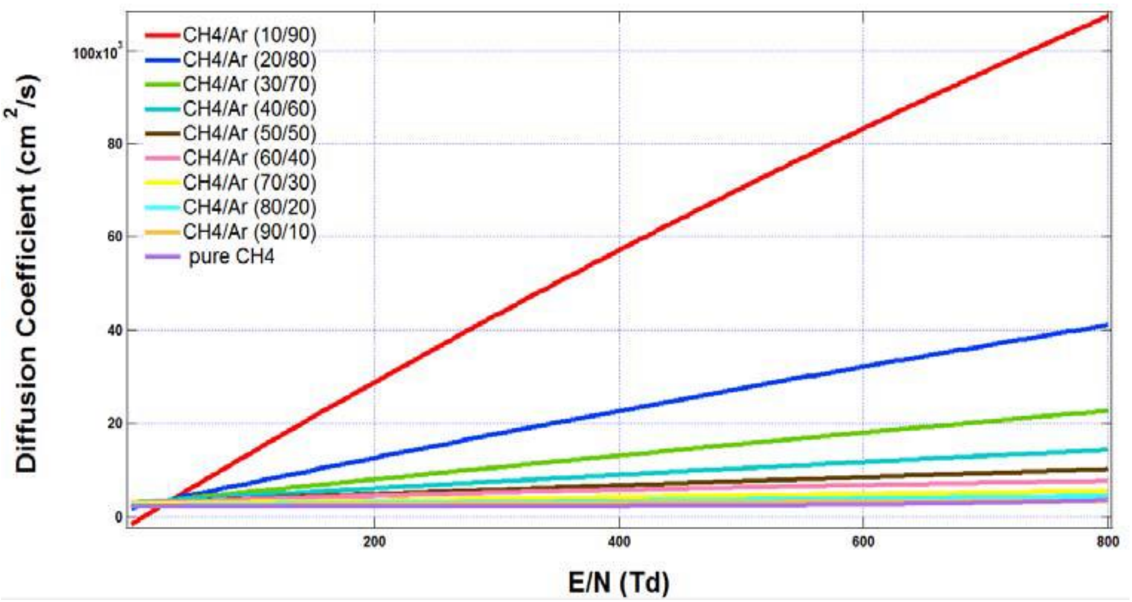

Figure (10) The diffusion coefficient as a function of E/N in different ratio of gas mixture CH4-Ar.

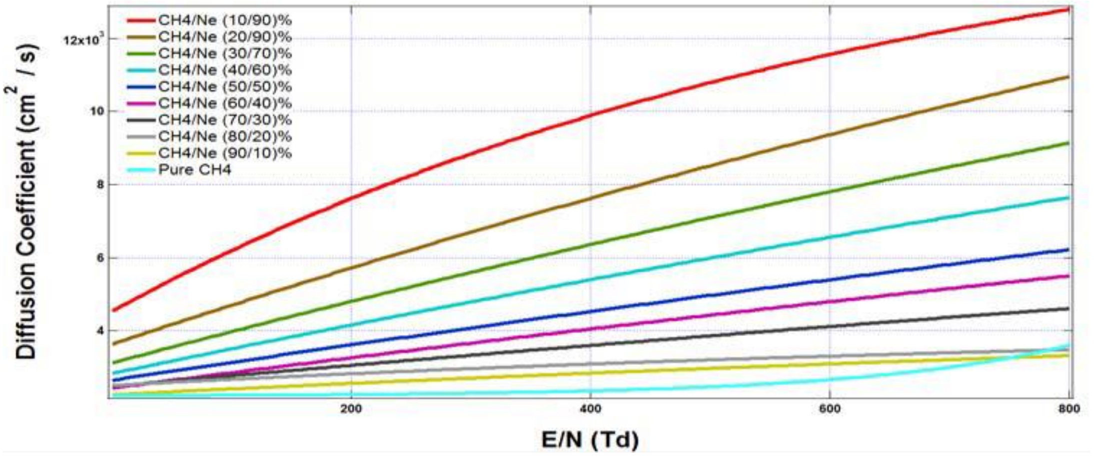

Figure (11) The Diffusion Coefficient as a function of E/N in different ratio of gas mixtures. (CH4-Ne).

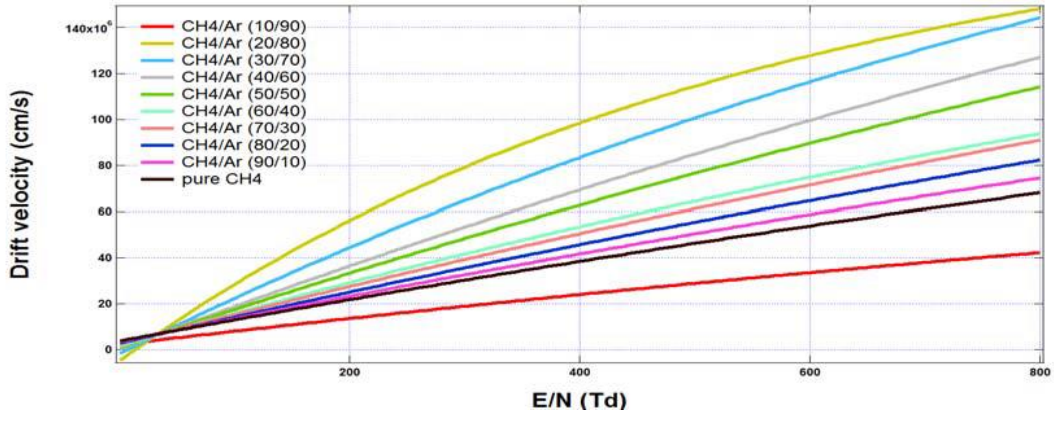

Figure (12) The drift velocity as a function of E/N in different ratio of gas mixtures (CH4-Ar).

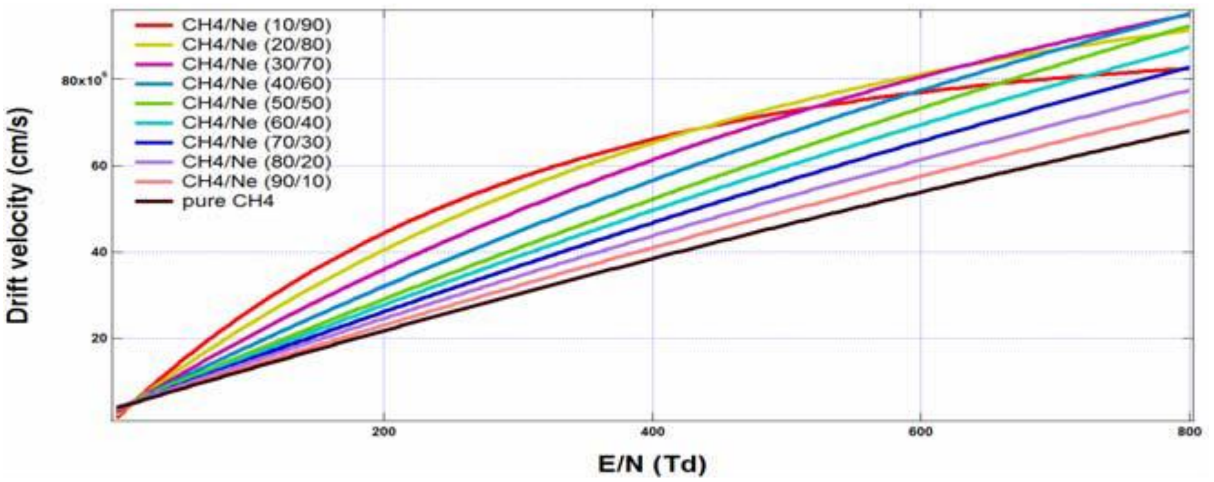

Figure (13) The drift velocity as a function of E/N in different ratio of gas mixtures (CH4-Ne).

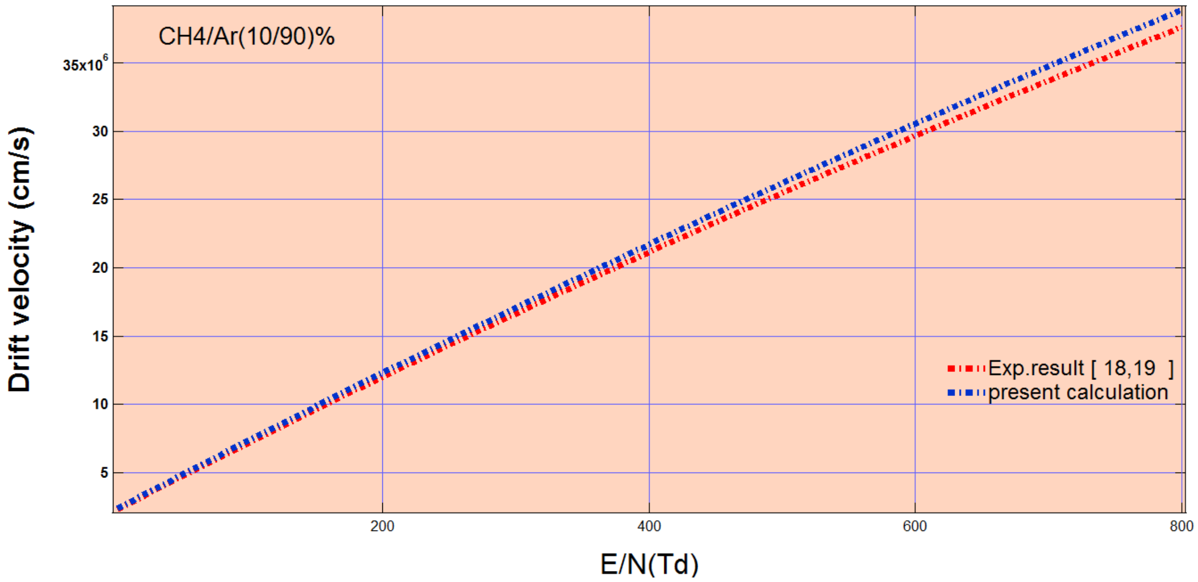

Figure (14) The drift velocity as a function of E/N in gas mixtures (CH4-Ar).

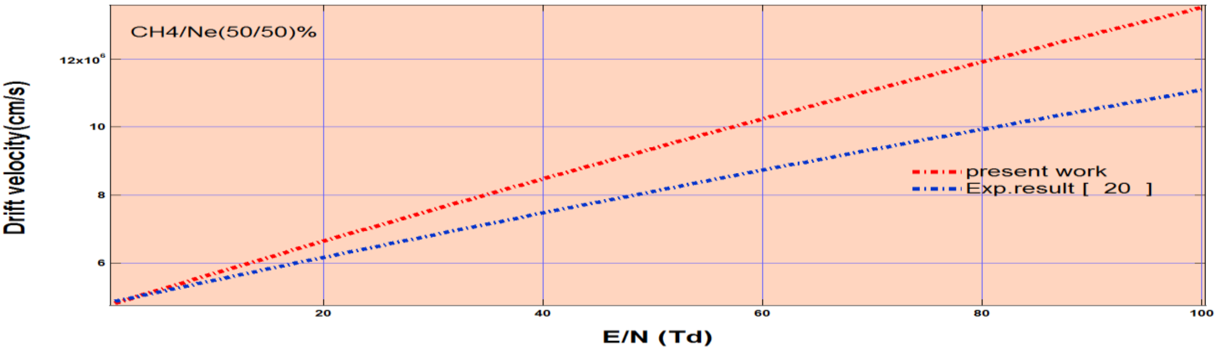

Figure (15) The drift velocity as a function of E/N in gas mixture (CH_4 -Ne) .

حسابات نظريه لمعاملات الانتقال الالكتروني لخليط غازي من $(CH_4\text{-}Ne)$ و $(CH_4\text{-}Ar)$ باستعمال طريقة مونتي كارلو

ايناس احمد جواد
قسم الفيزياء / كلية التربية للعلوم الصرفة (ابن الهيثم) / جامعة بغداد

استلم في:5 /حزيران/2016, قبل في:12/كانون الاول/2016

الخلاصه

تاثير تراكيز المختلفه لخليط الميثان مع غاز الاركون والنيون تؤخذ بالحسبان في دراسه التغير في دالة توزيع طاقة الالكترون وبالتالي تغير في معاملات انتقال الالكترونات مثل سرعة الانجراف ، متوسط الطاقة ، خصائص الطاقه ومكافيء الانتشار . في العمل الحالي استعمل برنامج محاكاة كومبيوتر متطور وحديث لحساب معاملات انتقال الاكترون.

الكلمات المفتاحية: معادلة بولتزمان ، خليط غاز ميثان – اركون ، ميثان- نيون ، بلازما والتفريغ الالكترون ، سرعة الانجراف ، معامل الانتشار ، معاملات الانتقال ، دالة التوزيع .