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SUBCOMMITTEE ON PLASMA CHEMISTRY*

THERMODYNAMIC AND TRANSPORT PROPERTIES OF PURE AND MIXED THERMAL PLASMAS AT LOCAL THERMODYNAMIC EQUILIBRIUM (LTE)

Prepared by the Task Group on Transport Phenomena in Thermal Plasmas consisting of
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PHYSICAL CHEMISTRY DIVISION
Subcommittee on Plasma Chemistry
Task Group on Transport Phenomena in Thermal Plasmas

THERMODYNAMIC AND TRANSPORT PROPERTIES OF PURE AND MIXED THERMAL PLASMAS AT LOCAL THERMODYNAMIC EQUILIBRIUM (LTE)

INTRODUCTION

Thermal plasmas produced at atmospheric pressure by arcs (direct or alternating current) or by r.f. discharges, with powers ranging from a few kW to a few MW, are increasingly used in industry since the early seventies. While plasma spray coating represents one of the first large scale industrial applications, plasma technology is now used for spheroidization (magnetite or ZrO_2...), for vaporization (production of ultra fine SiO_2 or TiO_2 pigment...), for extractive metallurgy (production of ferro-alloys...) and for chemical synthesis (C_2H_2, HCN, NO...). In all of these applications, a knowledge of the thermodynamic and transport properties of the different gases under plasma conditions is of prime importance. It is therefore not surprising that considerable effort has been devoted over the last two decades to the calculation and the experimental measurements of these properties under different conditions.

Realizing the importance of such fundamental data which seems to be scattered over a large number of different scientific journals and special publications of a rather limited circulation, the sub committee on Plasma Chemistry of the International Union of Pure and Applied Chemistry has appointed in July 1977 a Task group on "Transport Phenomena in Thermal Plasmas" under the chairmanship of Dr. Claude Bonet of the CNRS-Laboratoire des ultra-réfractaires, Odeillo, Font-Romeu, France. The mandate of this group was to conduct a review of the available scientific literature published over the period from 1950 to 1978 on the thermodynamic and transport properties of pure and mixed gases at atmospheric pressure under plasma conditions. Specifically, the following properties have been examined:

(a) Thermodynamic properties

- C_p and C_v heat capacity at constant pressure and constant volume
- h specific enthalpy

(b) Physical properties

- ρ density

(c) Transport properties

- k thermal conductivity
- η dynamic viscosity
- σ electrical conductivity
- D_{AB} diffusion coefficient

(d) Radiative properties

- ε_ν and ε spectral and total emission coefficient
- α_ν and α spectral and total absorption factors
- U radiation power per unit volume

The review was limited to thermal plasmas of the following pure gases or their mixtures at local thermodynamic equilibrium (LTE) at atmospheric pressure or above. Ar, He, N_2, H_2, O_2, CO_2, Air, Xe and Kr.

The collected bibliography was compiled in a standard format for quick reference identifying the properties studied by each worker, the gases, the temperature and pressure ranges covered. When ever possible, distinction was also made between experimental and theoretical investigations.

For ease of identification, each reference was attributed a six digit code. The first two digits giving the year of publication. This is followed by two digits corresponding to the alphabetical order of the first letter of the name of the first author. The last two digits is a serial number used to identify multiple publications by the same author in the same year. For example:

70-03-04, CAPITELLI M., "Equilibrium properties....between 5 000K and 35 000K", Rev. Int. Hautes températures et Réfractaires. 7, 153 (1970).

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70 - 03 - 04
↑    ↑    ↑
|    |    serial number
|    alphabetical order of the first author's name: C≡3
year of publication (1970)
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ACKNOWLEDGMENT

The contribution of the following members of the task group is acknowledged.

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PROPERTIES / AUTHORS	C_p, C_v h	ρ	K	η	σ		U ϵ_p	ϵ	α_ν	α	REMARKS
AESCHLIMAN - CAMBEL (70-01-01)				Ar							Experimental at 1 atm. 3500 < T < 8500 K
AMDUR - MASON (58-01-01)			He, Ne Ar, Kr Xe, N_2 He+Ar	He, Ne Ar, Kr Xe, N_2							Theoretical 10000 < T < 15000 K (He + Ar, mixture 50 %)
ANGELIN - ZANNIER (70-01-02)	N_2										Theoretical 4000 < T < 40000 K 0.01 < p < 10 atm.
ARTMANN - BOHN (66-01-01)		Ar, N_2 H_2	Ar, N_2	Ar, N_2	Ar, N_2						Theoretical 5000 < T < 35000 K 0.001 < p < 10 atm.
ASINOVSKII et al. (67-01-01)			N_2				N_2				Experimental and theoretical p = 1 atm. ; 1000 < T < 16000 K
ASINOVSKII et al. (68-01-01)								N_2			Continuous radiation for N_2 plasma (2500 to 20000 Å) p = 1 atm. ; 10000 < T < 16000 K
ASINOVSKII et al. (69-01-01)			Air		Air						Experimental 6000 < T < 14000 K p = 1 atm.
ASINOVSKII et al. (71-01-01)			Air CO_2	Air CO_2							Experimental 6000 < T < 15000 K p = 1 atm.
ASINOVSKII et al. (71-01-02)			Ar N_2 CO_2	Ar	Ar N_2 CO_2			Ar N_2 CO_2			Experimental 7000 < T < 16000 K
ASINOVSKII et al. (76-01-01)				Ar							Experimental 5000 < T < 11000 K p = 1 atm.
ASINOVSKII et al. (78-01-01)				Ar							Experimental 7000 < T < 11000 K p = 1 atm.
AUBRETON et al. (73-01-01)			N_2		N_2						Experimental T < 15000 K p = 1 atm.
AUBRETON et al. (73-01-02)			N_2		N_2						Theoretical T < 18000 K p = 1 atm.
BACRI et al. (73-02-01)									Ar+H_2		Comparison between experimental and calculated values T < 13000 K λ = 6965 Å
BAHADORI - SOO (66-02-01)			Ar	Ar	Ar						Experimental p = 1 atm. T < 6000 K
BARIFELD (77-02-01)								N_2			Theoretical includes a comparison with previous measurements
BARZELAY (66-02-04)								Ar			Experimental and theoretical
BAUDER-ZLOTNICK (59-02-01)			Air	Air							Theoretical p = 1 atm. 3000 < T < 8000 K
BAUDER (68-02-01)								Ar			Experimental and theoretical 9000 < T < 15000 K ; 1 < p < 100 atm.
BAUDER-BARTELHEIMER (70-02-01)					Ar						T < 2000 K ; 1 < p < 130 atm.

AUTHORS \ PROPERTIES	C_p, C_v h	ρ	K	η	σ		U ϵ_ν	ϵ	α_ν	α	REMARKS
BAUDER-MAECKER (71-02-01)			N_2 H_2		N_2 H_2						T < 26000 K ; p = 1 atm.
BAUDER et al. (75-02-01)					Air						Experimental 8000 < T < 14000 K p = 1 atm.
BAUDER (76-02-01)			H_2 Air N_2	N_2	Ar H_2 Air						Experimental 1 < p < 1000 atm. Ar T = 12000 K - H_2 T < 25000 K Air T < 13000 K - N_2 T < 28000 K
BAUDER (76-02-02)					Ar		Ar				Experimental p < 1000 atm. T < 16000 K
BECKER - BEZ (69-02-01)			Ar								Experimental
BEHRINGER - THOMA (75-02-02)							Ar				Experimental 12000 < T < 20000 K p = 1 atm. ; 1130 < ν < 3000 Å
BELOV et al. (75-02-03)			Ar					Ar			10500 < T < 12500 K Experimental for K 1 < p < 10 atm. ; for ϵ p = 50 atm.
BELYAEV-LEONAS (66-02-02)				N_2 O_2							Theoretical p = 1 atm. 2000 < T < 15000 K
BIBERMAN-MNATZAKANYAN (65-02-03)								Air	Air		Theoretical 4000 < T < 10000 K 0.01 < p < 100 atm.
BLAKE (70-02-02)			Air	Air							Theoretical
BLAKE (70-02-03)	Air		Air	Air							2000 < T < 15000 K Theoretical p = 1 atm. Values of Prandtl number
BONILLA et al. (56-02-01)				H_2O Ar D_2O							Experimental up to 15000 K at 1 atm.
BROKAW (67-02-02)			Ar	Ar							Theoretical and experimental 1000 < T < 30000 K ; p = 1 atm. Review
BROSSARD (62-02-01)	H_2	H_2									Theoretical T < 12000 K 0.2 < p < 6 atm.
BUES et al. (67-02-01)			Ar		Ar						Experimental
BURHORN (59-02-02)			N_2								Theoretical and measurement up to 13000 K
BURHORN-WIENECKE (60-02-01)	N_2 NO Air		N_2 NO Air								Theoretical at 1, 3, 10 and 30 atm. 1000 < T < 30000 K
BURHORN-WIENECKE (60-02-02)	H_2 H_2O										Theoretical at 1, 3, 10 and 30 atm. 1000 < T < 30000 K
BUTLER-BROKAW (57-02-01)			H_2 O_2								Theoretical
CAPITELLI et al. (69-03-01)	He + N_2 Ar + N_2 Xe + N_2										Mixed plasmas at 1 atm. 5000 < T < 35000 K
CAPITELLI-FICOCELLI (70-03-01)			He + N_2 Ar + N_2 Xe + N_2	He + N_2 Ar + N_2 Xe + N_2							Mixed plasmas at 1 atm. 5000 < T < 35000 K
CAPITELLI et al. (70-03-02)	Ar + O_2										Mixed plasmas 0.01 < p < 10 atm. 2000 < T < 35000 K

PROPERTIES / AUTHORS	C_p, C_v h	ρ	K	η	σ		U ϵ_p	ϵ	α_p	α	REMARKS
CAPITELLI (70-03-03)			$Ar + N_2$	$Ar + N_2$							$Ar-N_2$ MIXTURE AT 1 ATM. THEORETICAL $5000 < T < 15000$ K
CAPITELLI (70-03-04)	$He + N_2$ $Ar + N_2$ $Xe + N_2$										THEORETICAL AT 1 ATM. $5000 < T < 35000$ K
CAPITELLI ET AL. (72-03-01)	$Ar + H_2$										$0.01 < p < 1000$ ATM. $2000 < T < 35000$ K
CAPITELLI-DEVOTO (73-03-01)			N_2	N_2	N_2						THEORETICAL $5000 < T < 35000$ K
CAPITELLI-DEVOTO (73-03-02)			N_2		N_2						THEORETICAL AT 1 ATM. $8000 < T < 24000$ K
CAPITELLI (74-03-01)			H_2								THEORETICAL $10000 < T < 25000$ K
CAPITELLI ET AL. (75-03-01)			$Ar + N_2$	$Ar + N_2$							THEORETICAL AT 1 ATM. $9000 < T < 15000$ K
CAPITELLI ET AL. (77-03-01)	$Ar + H_2$										THEORETICAL AT 0.01, 1, 100 ATM. $5000 < T < 20000$ K $Ar-H_2$ MIXTURE 50 %
CAPITELLI (77-03-02)			N_2	AR							THEORETICAL AT 1 ATM. $10000 < T < 20000$ K
CARNEVALE (67-03-01)				AR, HE							EXPERIMENTAL $200 < T < 8000$ K $p = 1$ ATM.
CHIH WU (73-03-03)			AR AR + MGO	AR AR + MGO	AR AR + MGO						THEORETICAL AT 1 ATM. $700 < T < 3000$ K COMPARISON WITH MEASUREMENTS
CHOWDURY (69-03-02)		AR									THEORETICAL $5000 < T < 45000$ K ; $p = 1$ ATM. COMPOSITION AT SPECIFIC N_E
DARRIGO (70-04-01)			AR, HE	AR	AR						THEORETICAL $1000 < T < 5000$ K ; $p = 1$ ATM.
DELPECH-GAUTHIER (69-04-01)			ELEC-TRON GAS								THEORETICAL AND EXPERIMENTAL
DEVOTO (66-04-01) (67-04-01) (67-04-02)			AR	AR	AR						THEORETICAL $p = 1$ ATM. $5000 < T < 20000$ K
DEVOTO (73-04-01)			AR	AR	AR						THEORETICAL $0.001 < p < 1000$ ATM. $T < 35000$ K
DEVOTO (76-04-01)			AIR		AIR						$1 < p < 100$ ATM. $2000 < T < 20000$ K
DEVOTO ET AL. (78-04-01)			AIR		AIR						EXPERIMENTAL MEASUREMENTS $p = 1$ ATM. $T < 14000$ K
DRELLISHAK ET AL. (63-04-01)	AR	AR									THEORETICAL TABULATED FOR 0.1 TO 5 ATM. $5000 < T < 35000$ K
DRELLISHAK (64-04-01)	AR, N_2 O_2	AR, N_2 O_2									THEORETICAL TABULATED FOR 0.01, 0.1, 0.5, 1, 2 AND 5 ATM. UP TO 35000 K
DYMOND (71-04-01)			AR	AR							THEORETICAL $1500 < T < 7000$ K ; $p = 1$ ATM.

PROPERTIES / AUTHORS	C_p, C_v h	ρ	K	η	σ		U ϵ_ν	ϵ	α_ν	α	REMARKS
EMMONS (67-05-01)			Ar		Ar			Ar			Experimental 7000 < T < 35000 K
ERNST et al. (73-05-01)			N_2		N_2		N_2				Experimental up to 27000 K p = 1 atm.
de L'ESTOILE (61-05-01)							Air	Air			Comparison of theoretical and experimental results 2000 < T < 18000 K ; 0.0001 < p < 10 atm.
EVANS-TANKIN (67-05-02)								Ar		Ar	Measurement at 0.5, 1 and 2 atm. 10000 < T < 26000 K
EWALD-GRONIG (71-05-01)			Ar								Experimental T = 4800 K ; p = 1 atm.
FAUBERT-SPRINGER (72-06-01)			Ar, N_2								Experimental 800 < T < 2000 K ; p = 1 atm.
FAUCHAIS-MANSON (65-06-01)	H_2										Comparison of different theoretical models 0.01 < p < 100 atm. 10000 < T < 25000 K
FAUCHAIS (68-06-01)	H_2, N_2 H_2, N_2				H_2						0.01 < p < 100 atm. 2000 < T < 50000 K
FISHER et al. (69-06-01)					Ar, Kr Ne, He						Experimental measurements T < 22000 K
FRATZSCHER et al. (75-06-01)	N_2,H_2 O_2,S_2 F_2,Cl_2										Theoretical T < 10000 K
GLASSER et al. (73-07-01)							He				Experimental p = 1 atm. (2500 to 6000 Å)
GOLDBACH-NOLLEZ (72-07-01)									Ar		Experimental at 1, 10 and 30 atm. (3000 to 7000 Å)
GOLUBEV et al. (65-07-01)								H_2O			Theoretical and experimental p = 1 atm. ; 10000 < T < 18000 K
GORELOVA et al. (69-07-01)					Air						Measurements schock wave
GORSE (75-07-01)			N_2,H_2 Ar Ar + N_2 Ar + H_2	Ar + N_2 Ar + H_2	N_2, H_2 Ar Ar + N_2 Ar + H_2						Theoretical Ar-N_2 5000 < T < 20000 K Ar-H_2 2000 < T < 25000 K
GRYAZNOV et al. (76-07-01)					Ar Xe						Schock compressed
GUEVARA et al. (69-07-02)				Ar, He N_2, H_2							Experimental 1100 < T < 2150 ; p = 1 atm.
GÜNTHER et al. (76-07-02)					H_2						Theoretical and experimental p = 10 atm. ; 14000 < T < 22000 K
HANSEN (58-08-01) (59-08-01)	Air		Air	Air							Calculations 0.001 < p < 100 atm. 500 < T < 15000 K
HANSEN et al. (59-08-02)			Air								Experimental and theoretical
HARTUNIAN-MARRONE (61-08-01)				O_2							Measurements in a shock tube

PROPERTIES / AUTHORS	C_p, C_v h	ρ	K	η	σ		U ϵ_r	ϵ	α_p	α	REMARKS
HERMANN-SCHADE (70-08-01)			N_2		N_2			N_2			Experimental and theoretical at 1 atm. 5000 < T < 26000 K
INABA-KITO (76-09-01)			Ar + N_2		Ar + N_2						Theoretical 1000 < T < 20000 K ; p = 1 atm.
IRMER-WORM (74-09-01)		Ar, He									Theoretical ; Number densities 1000 < T < 20000 K ; 1 < p < 50 atm.
JORDAN-SWIFT (73-10-01)			Ar + N_2		Ar + N_2						
KAMNEV-LEONAS (66-11-01)			Kr Xe	Kr Xe							p = 1 atm. ; 2000 < T < 10000 K
KANNAPAN-BOSE (77-11-01)			Ar	Ar	Ar						Theoretical 0.001 < p < 1000 atm. 5000 < T < 20000 K
KHOMKIN (74-11-02)					Ar Xe						Calculations p = 1 atm. 5000 < T < 20000 K
KHOMKIN (78-11-01)					H_2, A Xe, Kr						Theoretical calculation at p = 15 atm. 10000 ⩽ T < 20000 K
KNOPP et al. (65-11-01)			N_2								Measurements T < 25000 K
KNOPP-CAMBEL (66-11-02)			Ar		Ar						Experimental and theoretical p = 1 atm. ; 8500 < T < 12000 K
KON'KOV et al. (73-11-01)							Xe		Air H_2, Kr O_2, N_2		Experimental 5000 < T < 30000 K 3 < p < 150 atm.
KON'KOV-KULAGIN (74-11-03)							Ar		Ar		Measurements 12000 < T < 16000 K
KREY-MORRIS (70-11-01)								N_2, O_2 Ar			Experimental at 1 atm. 9000 < T < 15000 K
KRINBERG (65-11-02)			N_2, O_2 H_2, Air								Theoretical at 1 atm. 300 < T < 20000 K
KUDASHEV-SERDYUK (69-11-01)			N_2, O_2 H_2, Ar He, CO CH_4, C_2H_4								1 < p < 300 atm. ; T < 10000 K
KULESSA (74-11-01)	Ar-H_2	Ar-H_2									Theoretical T < 25000 K
KULIK et al. (63-11-01)			Ar	Ar							Theoretical 5000 < T < 10000 K
KULIK-PANEVIN (67-11-01)			Air	Air							Theoretical 0.001 < p < 10 atm. 8000 < T < 22000 K
KULIK (71-11-01)			Ar	Ar							Theoretical 2000 < T < 12000 K
LAVUSHEV-LYUSTERNIK (76-12-01)				O_2							Measurements at 1 atm. up to 2000 K
LEE-INCROPERA (73-12-01)							Ar	Ar			Calculations p = 1 atm.

PROPERTIES / AUTHORS	C_p, C_v h	ρ	K	η	σ		U ε_ν	ε	α_ν	α	REMARKS
LEWIS RESEARCH CENTER (70-12-01)			Ar, H_2 NO_2, HF	Ar							0.001 < p < 100 atm. T < 30000 K
LEWIS J.A. (71-12-01)	Ar, N_2 O_2, He	Ar, N_2 O_2, He	Ar, N_2 O_2, He	Ar, N_2 O_2, He							Calculations 300 < T < 13200 K
LICK-EMMONS (62-12-01)	He										0.0001 < p < 1000 atm. 5000 < T < 50000 K
LICK-EMMONS (65-12-01)			He	He	He						0.0001 < p < 1000 atm. 200 < T < 50000 K
LOGAN (58-12-01)							Air		Air		Review 3000 < T < 10000 K
LOWKE (73-12-02)								Air			p = 30 atm. ; 8000 < T < 24000 K
MAECKER (62-13-01)			N_2	N_2	N_2						Experimental T < 15000 K
MAITLAND-SMITH (72-13-01)				Ar, He N_2, O_2 H_2 Air							Theoretical and experimental T < 2000 K ; p = 1 atm. Review
MARTINEK (59-13-01)	N_2 N, N^+				N_2						0.2 < p < 100 atm. 5000 < T < 35000 K
MASLOV et al. (70-13-01)	N_2	N_2	N_2								Theoretical 0.2 < p < 100 atm. 5000 < T < 40000 K
MASON-SAXENA (58-13-01)			$H_2 + O_2$ $H_2 + N_2$ $H_2 + N_2O$ $N_2 + CO_2$ $H_2 + C_2H_4$								Theoretical
MENSING-BOEDEKER (69-13-01)			Ar					Ar			Compilation of data
MILLER-SANDLER (73-13-01)			Ar		Ar						Two-temperature argon plasma Theoretical 10000 < T_E < 50000 K
MORRIS et al. (66-13-01)							N_2				Experimental 9000 < T < 13500 K ; p = 1,2 atm.
MORRIS et al. (70-13-02)			N_2, H_2 Ar		N_2, H_2 Ar						Experimental 0.5 < p < 2 atm. 8000 < T < 15000 K
MOSKVIN (68-13-01)								H_2, H_2O Ar, He NH_3			Theoretical 1 < p < 1000 atm. 6000 < T < 12000 K
MYRONUK-SOO (71-13-01)											Estimation of Prandtl number Measurements 2000 < T < 13000 K
NELSON (71-14-01) (72-14-01)	H_2 + He										Theoretical 10000 < T < 100000 K
NEUBERGER (73-14-01) (75-14-01)					N_2			N_2			Theoretical at 1 atm. 6000 < T < 30000 K

AUTHORS \ PROPERTIES	C_p, C_v h	ρ	K	η	σ		U ϵ_ν	ϵ	α_ν	α	REMARKS
NEUDER (70-14-01)							Ne, Ar Kr, Xe mixed				Measurements $3 < p < 18$ atm. 0,25 to 2,5 μm
OTT (73-15-01)							H_2				Experimental uv (2000 to 4000 Å)
PAKHOMOV-SAUTKIN (72-16-01)				N_2 Air							Measurements at 1 atm. $T < 15000$ K
PALKINA-SMIRNOV (74-16-01)			He, Ar Ne, Xe Kr	He Xe							Theoretical $2000 < T < 12000$ K
PENG-PINDROH (62-16-01)			Air	Air	Air						Theoretical $500 < T < 15000$ K
PENSKY (62-16-02)	Ar	Ar									Theoretical $T < 100000$ K ; p = 1 atm.
PLANTIKOW (69-16-01) (70-16-02)			N_2		N_2						Experimental and calculations at 1 atm. $5000 < T < 13000$ K
POLYAKOV (70-16-01)				Air							Experimental p = 1000 atm. $1000 < T < 5000$ K
POPOVIĆ et al. (76-16-01)			H_2		H_2						Theoretical explanation of experimental results p = 1 atm. $10000 < T < 30000$ K
ROGOV (70-18-01)			Ar Xe		Ar Xe						Simple formulas derived for computing K and σ
ROTHER (70-18-02)				N_2							Experimental at 1 atm.
SAMUILOV-TSITELAURI (70-19-01) (70-19-02)			Air								Comparison of experimental and theoretical results p = 1 atm. $T < 8000$ K
SANDLER-MILLER (70-19-03)			Ar		Ar						p = 1 atm. ; $T < 10000$ K
SANDLER (73-19-01)			Ar He + H_2		Ar						Compilation of experimental and theoretical results
SÄNGER-BREDT (59-19-01)	H_2 H_2O										$0.001 < p < 10$ atm. ; $500 < T < 10000$ K
SCALA-BAULKNIGHT (59-19-02)	Air		Air	Air							p = 1 atm. ; $T < 16000$ K
SCHMITZ-PATT (63-19-01)			N_2		N_2			N_2			Measurements at 1 atm. up to 15000 K
SCHREIBER et al. (70-19-04)				N_2							Experimental measurements p = 1 atm. ; $9000 < T < 15000$ K
SCHREIBER et al. (71-19-01)				Ar N_2							Experimental $8000 < T < 14000$ K
SCHREIBER et al. (72-19-01)			N_2		N_2		N_2				Experimental p = 1 atm. $10500 < T < 12250$ K
SCHREIBER et al. (73-19-02)					Air		Air	Air			Experimental $8000 < T < 12500$ K

PROPERTIES / AUTHORS	C_p, C_v h	ρ	K	η	σ		U ϵ_ν	ϵ	α_ν	α	REMARKS
SERGIENKO-FOKOV (77-19-01)			Ar		Ar						T < 16000 K
SHAYLER-FANG (77-19-02)			Cu - N_2		Cu-N_2						Mixture of Cu-N_2, calculated values 1<p<10 atm. ; 2000<T<28000 K
SINAISKY et al. (75-19-01)					Ar						Mixture of argon and aluminum particles T < 50000 K
SKRIVAN-JASKOWSKY (65-19-01)	Ar, N_2 H_2		Ar, N_2 H_2	Ar, N_2 H_2							Compilation of theoretical results p = 1 atm. ; T < 5000 K
SPRINGER-WINGEIER (73-19-03)			Ar								Theoretical and experimental 800 < T < 2500 K ; p = 1 atm.
TAN et al. (65-20-01)			Ar	Ar	Ar						Theoretical and experimental p = 1 atm. ; T < 28000 K
THOMAS (62-20-01)			Air CO_2		Air CO_2						0.001 < p < 1000 atm. T < 24000 K
THOMAS-PENNER (64-20-01)			Air							Air	Theoretical 0.0001 < p < 10 atm. T < 230000 K
UHLENBUSH (64-21-01)			N_2 Ar		N_2 Ar			N_2 Ar			Measurements in the arc at 1 atm.
UHLENBUSCH (72-21-01)			H_2, Ar N_2	Ar, He	Ar, He H_2, N_2 Kr, Xe						Theoretical and experimental up to 30000 K
ULYBIN (67-21-01) (68-21-01)				H_2+N_2 H_2+CO							Calculations
VARGAFTIK (75-22-01)	Ar, N_2 O_2	Ar, N_2	Ar, N_2 O_2	Ar, N_2 O_2	N_2						Compilation of literature data
VARGIN et al. (72-22-01)							Air				Calculations p = 1 atm., T = 10000 K uv (1400 to 2200 Å)
VOLKOV et al. (78-22-01)							Ar		Ar		Measurements T = 20000 K p = 40 atm.
VOROB'EV-KHOMKIN (77-22-01)					Ar Cs + Xe						Theoretical, comparison with experiments
WILKE (50-23-01)				He + Ar N_2 + O_2 H_2 + Ar							Calculations of viscosity for binary and multicomponent mixtures function of composition
YUN et al. (62-25-01)			N_2, O_2	N_2, O_2							Theoretical transport coefficients at 0.1, 1 and 10 atm. tabulated as a function of temperature 1000 < T < 10000 K

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