Appendix B. Nomenclature

Acronyms

BL	Boundary layer
CE	Chapman & Enskog's transport model
CNE	Chemical non-equilibrium
CPG	Calorically perfect gas
DNS	Direct numerical simulations
LPSE	Linear parabolized stability equations
LST	Linear stability theory
LTEED	Local thermochemical equilibrium with elemental demixing
LTE	Local thermochemical equilibrium (without elemental demixing)
NPSE	Non-linear parabolized stability equations
RRHO	Rigid rotor and harmonic oscillator thermal model
SCEBAD	Self-consistent effective binary ambipolar diffusion
TCNE	Thermo-chemical non-equilibrium
TNE	Thermal non-equilibrium (yet frozen chemistry)
TPG	Thermally perfect gas (frozen)
TPS	Thermal protection system

Roman Symbols

a^{Fr}	Frozen speed of sound (Eq. 4.1) [m/s]
$A_{B^*_{s\ell}}, \cdots, F_{B^*_{s\ell}}$	Polynomial curve-fit coefficients for collision integral ratios $B^*_{s\ell}$ [–]
A^f_r	Arrhenius pre-exponential constant (for property Q) [$[Q]$ K$^{-n_{Tr}}$]
$A_{\Omega^{(i,j)}_{s\ell}}, \cdots, F_{\Omega^{(i,j)}_{s\ell}}$	Polynomial curve-fit coefficients for collision integral $\Omega^{(i,j)}_{s\ell}$ [–]
$B^*_{s\ell}$	Ratio of collision integrals (Eq. A 12a) [–]
c_p	Heat capacity at constant p [J/kg-K]
$C^*_{s\ell}$	Ratio of collision integrals (Eq. A 12b) [–]
c_v	Heat capacity at constant volume [J/kg-K]
d^j_s	Species diffusion driving force [1/m]
$\mathcal{D}_{\text{eff}\,s}$	Effective diffusion coefficient of species s in the mixture [m^2/s]
$\mathcal{D}_{s\ell}$	Multicomponent diffusion coefficient of species s in species ℓ [m^2/s]
$\mathscr{D}_{s\ell}$	Binary diffusion coefficient of the species pair $s-\ell$ [m^2/s]
$\mathcal{E}$	Set of all elements [–]
e	Internal energy [J/kg]
F	Perturbation frequency [Hz]
g^{ij}	Contravariant metric tensor $\left(=(g_{ij})^{-1}\right)$ [–]
g_{ij}	Covariant metric tensor ($=\delta_{ij}$ for Cartesian coordinate system) [–]
$G^{\kappa_H}_{s\ell}$	Heavy-particle translational thermal conductivity matrix subsystem [K m/W]
$G^{\mu}_{s\ell}$	Viscosity matrix subsystem [m s/kg]
g^{Elec}_{sm}	Degeneracy of the m-th electronic energy level of species s [–]
g^{Vib}_{sm}	Degeneracy of the m-th vibrational mode of species s [–]
$\hbar$	Planck's constant ($=6.626070040\cdot10^{-34}$) [J s]
$\mathcal{H}$	Set of all heavy species (not electrons) [–]
h	Static enthalpy per unit mass [J/kg]
$h^\circ_{f\,s}$	Species formation enthalpy at 0K [J/kg]
$H^{298\,\text{K}}_{f\,s}$	Species formation enthalpy at 298K [J/mol]
i, j, k, l	Sub- and super-indices corresponding to the spatial directions in co- or contravariant variables the tensorial notation. Other indices **do not correspond to tensorial directions**. [–]

$\mathcal{J}^j$ Energy diffusion flux [J/m^2-s]
J_E^j Elemental diffusion flux of element E [kg/m^2-s]
J_s^j Mass diffusion flux of species s [kg/m^2-s]
k_B Boltzmann's constant ($= 1.38064852 \cdot 10^{-23}$) [m^2-kg/K-s^2]
$k_{b\,r}$ Backward reaction rate [(m^3/mol)$^{\sum_s \nu''_{sr}-1}$ s^{-1}]
$K_{\mathrm{eq}\,r}$ Chemical equilibrium constant [(m^3/mol)$^{\sum_s \nu'_{sr}-\nu''_{sr}}$]
$k_{f\,r}$ Forward reaction rate [(m^3/mol)$^{\sum_s \nu'_{sr}-1}$ s^{-1}]
$\mathcal{L}_s$ Molecule's linearity factor (3 for non-linear and 2 for linear) [–]
$\mathscr{M}$ Molar mass [kg/mol]
n Number density [particle/m^3]
N_A Avogadro's number ($= 6.022140857 \cdot 10^{23}$) [particles/mol]
n_{Tr}^f Arrhenius temperature exponential constant [–]
p Pressure [Pa]
$\mathcal{Q}$ Partition function [–]
q_{e^-} Elementary charge ($= 1.6021766208981 \cdot 10^{-19}$) [C]
$\mathcal{R}$ Set of all reactions [–]
$\mathscr{R}$ Universal gas constant ($= 8.31447$) [J/mol-K]
R Mixture-specific gas constant ($= \mathscr{R}/\mathscr{M}$) [J/kg-K]
$\mathcal{S}$ Set of all species [–]
$\mathcal{S}_{\mathrm{ion}}$ Set of ion (positively charged) species [–]
$\mathcal{S}_{\mathrm{mol}}$ Set of all molecular species [–]
$\mathbb{T}^{ij}$ Viscous stress tensor [Pa]
T Temperature [K]
t Time [s]
T^* Reduced temperature (Eq. A 9) [K]
$\mathscr{U}^j$ Velocity components in a Cartesian reference system [m]
u^j Velocity components in tensorial notation [m/s]
$\mathscr{X}^j$ Spatial coordinates in a Cartesian reference system [m]
x^j Spatial coordinates in tensorial notation [m]
X_s Mole fraction of species s ($= Y_s\mathscr{M}/\mathscr{M}_s$) [–]
x, y, z Spatial coordinates [m]
$\mathcal{Y}_E$ Mass fraction of element E ($= \rho_E/\rho$) [–]
Y_s Mass fraction of species s ($= \rho_s/\rho$) [–]
$\mathcal{Z}_s$ Unitary charge of species s [–]

Greek Symbols

α Perturbation streamwise wavenumber [1/m]
β Perturbation spanwise wavenumber [1/m]
δ_{ab} Kronecker delta function (1 for $a = b$, 0 otherwise) [–]
ϵ_0 Permittivity of vacuum ($= 8.854187817620 \cdot 10^{-12}$) [C^2/N-m^2]
γ Ratio of specific heats ($= c_p/c_v$) [–]
Γ_{ik}^j Christoffel symbol of the second kind (Eq. 2.3) [1/[x^k]]
η Self-similar boundary-layer variable (Eq. 3.4) [–]
θ_{sm}^{Elec} Activation temperature of the m-th electronic energy level of species s [K]
θ_r^f Arrhenius activation temperature of reaction r [K]
θ_s^{Rot} Rotational activation temperature [K]
θ_{sm}^{Vib} Activation temperature of the m-th vibrational mode of species s [K]
κ^{Fr} Frozen thermal conductivity [W/K-m]

κ^{eq}	Equilibrium thermal conductivity (Eq. 2.14) [W/K-m]
λ	Second viscosity coefficient [kg/m-s]
λ_D	Debye shielding length [m]
$\Lambda_{s\ell}^{(i,j)}$	Laguerre-Sonine polynomials in the expressions of $\kappa_{\text{e}^-}^{Trans}$ [K-m/W]
μ	Dynamic viscosity [kg/m-s]
ν'_{sr}, ν''_{sr}	Stoichiometric coefficient for reactants & products s in reaction r [–]
ξ	Marching boundary-layer variable (Eq. 3.4) [–]
ρ	Mass density [kg/m^3]
σ_s	Molecule's steric factor (2 for symmetric, 1 for non-symmetric) [–]
ω	Perturbation frequency [1/s]
$\Omega_{s\ell}^{(i,j)}$	Collision integral of order (i,j) between species s and ℓ [m^2]
$\dot{\omega}_s$	Species production rate [kg/m^3-s]

Sub- and superscripts

q	Total flow quantity
$\bar{q}$	Laminar base-flow quantity
q'	Perturbation quantity
$\tilde{q}$	Perturbation amplitude quantity
$q_{\Re}$	Real part of a complex variable
$q_{\Im}$	Imaginary part of a complex variable
q^i	Contravariant vector quantity
q^{ij}	Contravariant tensor quantity
q_i	Covariant vector quantity
q_{ij}	Covariant tensor quantity
$q_{,i}$	Covariant derivative of a quantity
q_{e^-}	Electron-species-specific quantity
q_e	Boundary-layer-edge quantity
q_E, q_F	Element-specific quantity
q_{EF}	Element-pair-specific quantity
q^{Mod}	Referred to the different energy modes
q_r	Reaction quantity
q_s, q_ℓ	Species-specific quantity
$q_{s\ell}$	Species-pair-specific quantity