1 Variables

2 root

	var	symbol	documentation	type	units	eqs
10	$F_{N,A}$	`F`	basic directed graph incidence matrix	network		
48	$I_{NAN,A}$	`I_N_A`	project node on arc	projection		
9	Δ	`pulse`	pulse of length time interval	frame		7
4	t	`t`	time	frame	s	
6	t^e	`te`	time end	frame	s	4
7	Δt	`t_interval`	time interval	frame	s	5
5	t^o	`to`	time zero	frame	s	3
2	1	`one`	numerical one	constant		1
1	#	`value`	numerical value	constant		
3	0	`zero`	numerical value zero	constant		2
8	0.5	`onehalf`	numerical one half	constant		6

3 physical

	var	symbol	documentation	type	units	eqs
13	r_{yN}	`r_y`	y-direction	frame	m	9
14	r_{zN}	`r_z`	z-direction	frame	m	10
11	ℓ_N	`l`	length	frame	m	
12	r_{xN}	`r_x`	x-direction	frame	m	8
25	C_N	`C`	fundamental state - charge	state	$A\,s$	
15	V_N	`V`	fundamental state - volume	state	m^3	11
24	G_N	`G`	Gibbs free energy	state	$kg\,m^2\,s^{-2}$	18
22	H_N	`H`	Enthalpy	state	$kg\,m^2\,s^{-2}$	15
23	A_N	`A`	Helmholts energy	state	$kg\,m^2\,s^{-2}$	17
18	$n_{N,S}$	`n`	fundamental state - molar mass	state	mol	
16	U_N	`U`	fundamental state - internal energy	state	$kg\,m^2\,s^{-2}$	
17	S_N	`S`	fundamental state - entropy	state	$kg\,m^2\,K^{-1}\,s^{-2}$	
32	A^v	`Av`	Avogadro number	constant	mol^{-1}	
33	B_N	`Boltz`	Boltzmann constant	constant	$kg\,m^2\,K^{-1}\,s^{-2}$	24
34	R_N	`R`	Gas constant	constant	$kg\,m^2\,mol^{-1}\,K^{-1}\,s^{-2}$	25
35	${U^e}_N$	`Ue`	electrical potential – voltage	effort	$kg\,m^2\,A^{-1}s^{-3}$	26
19	T_N	`T`	temperature	effort	K	16
20	p_N	`p`	pressure	effort	$kg\,m^{-1}\,s^{-2}$	13
21	$\mu_{N,S}$	`chemPot`	chemical potential	effort	$kg\,m^2\,mol^{-1}\,s^{-2}$	14
29	v_{zN}	`v_z`	velocity in z-direction	secondaryState	ms^{-1}	21
28	v_{yN}	`v_y`	velocity in y-direction	secondaryState	ms^{-1}	20
27	v_{xN}	`v_x`	velocity in x-direction	secondaryState	ms^{-1}	19

4 material

	var	symbol	documentation	type	units	eqs
46	k^c_{zN}	kc_z	convective mass conductivity in z-direction	property	$m^{-1}\,s$	37
51	k^c_{zA}	kc_z_A	convective mass conductivity in z-direction in arc	property	$m^{-1}\,s$	41
58	m_N	m	mass	property	kg	48
42	$k^d_{yN,S}$	kd_y	diffusional mass conductivity in z-direction	property	$kg^{-1}\,m^{-4}\,mol^2\,s$	33
63	$k^(d, Fick_{zA,S}$	kd_z_Fick	Fick's diffusivity in arc and z-direction	property	ms^{-1}	53
37	C_{vN}	Cv	total heat capacity at constant volume	property	$kg\,m^2\,K^{-1}\,s^{-2}$	28
38	k^q_{xN}	kq_x	thermal conductivity in x-direction	property	$kg\,K^{-1}\,s^{-3}$	29
49	k^c_{xA}	kc_x_A	convective mass conductivity in x-direction in arc	property	$m^{-1}\,s$	39
52	$k^d_{xA,S}$	kd_x_A	diffusional mass conductivity in x-direction in arc	property	$kg^{-1}\,m^{-4}\,mol^2\,s$	42
55	k^q_{xA}	kq_x_A	thermal conductivity in x-direction in arc	property	$kg\,K^{-1}\,s^{-3}$	45
61	$k^(d, Fick_{xA,S}$	kd_x_Fick	Fick's diffusivity in arc and x-direction	property	ms^{-1}	51
41	$k^d_{xN,S}$	kd_x	diffusional mass conductivity in x-direction	property	$kg^{-1}\,m^{-4}\,mol^2\,s$	32
43	$k^d_{zN,S}$	kd_z	diffusional mass conductivity in z-direction	property	$kg^{-1}\,m^{-4}\,mol^2\,s$	34
40	k^q_{zN}	kq_z	thermal conductivity in z-direction	property	$kg\,K^{-1}\,s^{-3}$	31
45	k^c_{yN}	kc_y	convective mass conductivity in y-direction	property	$m^{-1}\,s$	36
54	$k^d_{zA,S}$	kd_z_A	diffusional mass conductivity in z-direction in arc	property	$kg^{-1}\,m^{-4}\,mol^2\,s$	44
62	$k^(d, Fick_{yA,S}$	kd_y_Fick	Fick's diffusivity in arc and y-direction	property	ms^{-1}	52
53	$k^d_{yA,S}$	kd_y_A	diffusional mass conductivity in y-direction in arc	property	$kg^{-1}\,m^{-4}\,mol^2\,s$	43
47	$h_{N,S}$	h	partial molar enthalpies	property	$kg\,m^2\,mol^{-1}\,s^{-2}$	38
36	C_{pN}	Cp	total heat capacity at constant pressure	property	$kg\,m^2\,K^{-1}\,s^{-2}$	27
44	k^c_{xN}	kc_x	convective mass conductivity in x-direction	property	$m^{-1}\,s$	35
50	k^c_{yA}	kc_y_A	convective mass conductivity in y-direction in arc	property	$m^{-1}\,s$	40
60	v_S	v	molar volume of species	property	$m^3\,mol^{-1}$	50

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	var	symbol	documentation	type	units	eqs
26	λ_S	`Mm`	species' molecular mass	property	$kg\,mol^{-1}$	
57	k^q_{zA}	`kq_z_A`	thermal conductivity in z-direction in arc	property	$kg\,K^{-1}\,s^{-3}$	47
59	$density_N$	`density`	density	property	$kg\,m^{-3}$	49
39	k^q_{yN}	`kq_y`	thermal conductivity in y-direction	property	$kg\,K^{-1}\,s^{-3}$	30
56	k^q_{yA}	`kq_y_A`	thermal conductivity in y-direction in arc	property	$kg\,K^{-1}\,s^{-3}$	46

5 macroscopic

	var	symbol	documentation	type	units	eqs
83	$\hat{q}_{xA}$	`q_x_A`	heat flow in arc and x-direction	transport	$kg\,m^2\,s^{-3}$	72
68	A_{xyA}	`A_xy_A`	cross sectional area yz of arc	geometry	m^2	57
66	A_{xzN}	`A_xz`	cross sectional area xz	geometry	m^2	55
69	A_{xzA}	`A_xz_A`	cross sectional area xz of arc	geometry	m^2	58
65	A_{xyN}	`A_xy`	cross sectional area xy	geometry	m^2	54
70	A_{yzA}	`A_yz_A`	cross sectional area yz of arc	geometry	m^2	59
67	A_{yzN}	`A_yz`	cross sectional area yz	geometry	m^2	56
64	$D_{N,A}$	`D`	difference operator	differenceOperator		

6 material–macroscopic

	var	symbol	documentation	type	units	eqs
82	$\_k^q{}_{zA}$	`_kq_z_A`	link variable kq z A to interface material »> macroscopic	get	$kg\,K^{-1}\,s^{-3}$	71
75	${}_kd_{xF}ick_{A,S}$	`_kd_x_Fick`	link variable kd x Fick to interface material »> macroscopic	get	ms^{-1}	64
30	$\_\lambda_S$	`_Mm`	link variable Mm to interface material »> macroscopic	get	$kg\,mol^{-1}$	22
72	$\_k^c{}_{yA}$	`_kc_y_A`	link variable kc y A to interface material »> macroscopic	get	$m^{-1}\,s$	61
80	$\_k^q{}_{xA}$	`_kq_x_A`	link variable kq x A to interface material »> macroscopic	get	$kg\,K^{-1}\,s^{-3}$	69
71	$\_k^c{}_{xA}$	`_kc_x_A`	link variable kc x A to interface material »> macroscopic	get	$m^{-1}\,s$	60
73	$\_k^c{}_{zA}$	`_kc_z_A`	link variable kc z A to interface material »> macroscopic	get	$m^{-1}\,s$	62
74	$\_k^d{}_{xA,S}$	`_kd_x_A`	link variable kd x A to interface material »> macroscopic	get	$kg^{-1}\,m^{-4}\,mol^2\,s$	63
81	$\_k^q{}_{yA}$	`_kq_y_A`	link variable kq y A to interface material »> macroscopic	get	$kg\,K^{-1}\,s^{-3}$	70
79	${}_kd_{zF}ick_{A,S}$	`_kd_z_Fick`	link variable kd z Fick to interface material »> macroscopic	get	ms^{-1}	68
78	$\_k^d{}_{zA,S}$	`_kd_z_A`	link variable kd z A to interface material »> macroscopic	get	$kg^{-1}\,m^{-4}\,mol^2\,s$	67
76	${}_kd_{yF}ick_{A,S}$	`_kd_y_Fick`	link variable kd y Fick to interface material »> macroscopic	get	ms^{-1}	65
77	$\_k^d{}_{yA,S}$	`_kd_y_A`	link variable kd y A to interface material »> macroscopic	get	$kg^{-1}\,m^{-4}\,mol^2\,s$	66

7 Equations

8 Generic

no	equation	documentation	layer
1	$1 := \text{Instantiate}(\#, \#)$	numerical one	root
2	$0 := \text{Instantiate}(\#, \#)$	numerical value zero	root
3	$t^o := \text{Instantiate}(t, 0)$	time zero	root
4	$t^e := \text{Instantiate}(t, \#)$	time end	root
5	$\Delta t := \text{Instantiate}(t, \#)$	time interval	root
6	$0.5 := \text{Instantiate}(\#, \#)$	numerical one half	root
7	$\Delta := \text{sign}\,(t - t^o) - \text{sign}\,(t - (t^o - \Delta t))$	pulse of length time interval	root
8	$r_{xN} := \text{Instantiate}(\ell_N, \#)$	x-direction	physical
9	$r_{yN} := \text{Instantiate}(\ell_N, \#)$	y-direction	physical
10	$r_{zN} := \text{Instantiate}(\ell_N, \#)$	z-direction	physical
11	$V_N := r_{xN} \,.\, r_{yN} \,.\, r_{zN}$	volume	physical
13	$p_N := \frac{\partial U_N}{\partial V_N}$	pressure	physical
14	$\mu_{N,S} := \frac{\partial U_N}{\partial n_{N,S}}$	chemical potential	physical
15	$H_N := U_N - p_N \,.\, V_N$	Enthalpy	physical
16	$T_N := \frac{\partial U_N}{\partial S_N}$	temperature	physical
17	$A_N := U_N - T_N \,.\, S_N$	Helmholts energy	physical

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no	equation	documentation	layer
18	$G_N := U_N + p_N \,.\, V_N - T_N \,.\, S_N$	Gibbs free energy	physical
19	$v_{xN} := (t)^{-1} \,.\, r_{xN}$	velocity in x-direction	physical
20	$v_{yN} := (t)^{-1} \,.\, r_{yN}$	velocity in y-direction	physical
21	$v_{zN} := (t)^{-1} \,.\, r_{zN}$	velocity in z-direction	physical
24	$B_N := \text{Instantiate}(S_N, \#)$	Boltzmann constant	physical
25	$R_N := A^v \,.\, B_N$	Gas constant	physical
26	$U^e{}_N := (C_N)^{-1} \,.\, U_N$	electrical potential – voltage	physical
27	$C_{pN} := \frac{\partial H_N}{\partial T_N}$	total heat capacity at constant pressure	material
28	$C_{vN} := \frac{\partial U_N}{\partial T_N}$	total heat capacity at constant volume	material
29	$k^q_{xN} := (V_N)^{-1} \,.\, C_{pN} \,.\, v_{xN}$	thermal conductivity in x-direction	material
30	$k^q_{yN} := (V_N)^{-1} \,.\, C_{pN} \,.\, v_{yN}$	thermal conductivity in y-direction	material
31	$k^q_{zN} := (V_N)^{-1} \,.\, C_{pN} \,.\, v_{zN}$	thermal conductivity in z-direction	material
32	$k^d_{xN,S} := (\mu_{N,S})^{-1} \,.\, \left(v_{xN} \,.\, \left((V_N)^{-1} \,.\, \frac{\partial U_N}{\partial \mu_{N,S}}\right)\right)$	diffusional mass conductivity in x-direction	material
33	$k^d_{yN,S} := (\mu_{N,S})^{-1} \,.\, \left(v_{yN} \,.\, \left((V_N)^{-1} \,.\, \frac{\partial U_N}{\partial \mu_{N,S}}\right)\right)$	diffusional mass conductivity in y-direction	material
34	$k^d_{zN,S} := (\mu_{N,S})^{-1} \,.\, \left(v_{zN} \,.\, \left((V_N)^{-1} \,.\, \frac{\partial U_N}{\partial \mu_{N,S}}\right)\right)$	diffusional mass conductivity in z-direction	material
35	$k^c_{xN} := \left(\lambda_S \star (\mu_{N,S})^{-1}\right) \,.\, (V_N)^{-1} \,.\, \frac{\partial U_N}{\partial p_N} \,.\, v_{xN}$	convective mass conductivity in x-direction	material

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no	equation	documentation	layer
36	$k^c_{yN} := \left(\lambda_S \star (\mu_{N,S})^{-1}\right) \,.\, (V_N)^{-1} \,.\, \frac{\partial U_N}{\partial p_N} \,.\, v_{yN}$	convective mass conductivity in y-direction	material
37	$k^c_{zN} := \left(\lambda_S \star (\mu_{N,S})^{-1}\right) \,.\, (V_N)^{-1} \,.\, \frac{\partial U_N}{\partial p_N} \,.\, v_{zN}$	convective mass conductivity in z-direction	material
38	$h_{N,S} := H_N \,.\, (n_{N,S})^{-1}$	partial molar enthalpies	material
39	$k^c_{xA} := I_{NAN,A} \star k^c_{xN}$	convective mass conductivity in x-direction in arc	material
40	$k^c_{yA} := I_{NAN,A} \star k^c_{yN}$	convective mass conductivity in y-direction in arc	material
41	$k^c_{zA} := I_{NAN,A} \star k^c_{zN}$	convective mass conductivity in z-direction in arc	material
42	$k^d_{xA,S} := I_{NAN,A} \star k^d_{xN,S}$	diffusional mass conductivity in x-direction in arc	material
43	$k^d_{yA,S} := I_{NAN,A} \star k^d_{yN,S}$	diffusional mass conductivity in z-direction in arc	material
44	$k^d_{zA,S} := I_{NAN,A} \star k^d_{zN,S}$	diffusional mass conductivity in z-direction in arc	material
45	$k^q_{xA} := I_{NAN,A} \star k^q_{xN}$	thermal conductivity in x-direction in arc	material
46	$k^q_{yA} := I_{NAN,A} \star k^q_{yN}$	thermal conductivity in y-direction in arc	material
47	$k^q_{zA} := I_{NAN,A} \star k^q_{zN}$	thermal conductivity in z-direction in arc	material
48	$m_N := \lambda_S \star n_{N,S}$	mass	material

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no	equation	documentation	layer
49	$density_N := (V_N)^{-1} \,.\, m_N$	density	material
50	$v_S := V_N \star (n_{N,S})^{-1}$	molar volume of species	material
51	$k^(d, Fick_{xA,S} := I_{NAN,A} \star \left(v_{xN} \,.\, \frac{\partial U_N}{\partial \mu_{N,S}} \,.\, (n_{N,S})^{-1} \right)$	Fick's diffusivity in arc and x-direction	material
52	$k^(d, Fick_{yA,S} := I_{NAN,A} \star \left(v_{yN} \,.\, \frac{\partial U_N}{\partial \mu_{N,S}} \,.\, (n_{N,S})^{-1} \right)$	Fick's diffusivity in arc and y-direction	material
53	$k^(d, Fick_{zA,S} := I_{NAN,A} \star \left(v_{zN} \,.\, \frac{\partial U_N}{\partial \mu_{N,S}} \,.\, (n_{N,S})^{-1} \right)$	Fick's diffusivity in arc and z-direction	material
54	$A_{xyN} := r_{xN} \,.\, r_{yN}$	cross sectional area xy	macroscopic
55	$A_{xzN} := r_{xN} \,.\, r_{zN}$	cross sectional area xz	macroscopic
56	$A_{yzN} := r_{yN} \,.\, r_{zN}$	cross sectional area yz	macroscopic
57	$A_{xyA} := I_{NAN,A} \star A_{xyN}$	cross sectional area yz of arc	macroscopic
58	$A_{xzA} := I_{NAN,A} \star A_{xzN}$	cross sectional area xz of arc	macroscopic
59	$A_{yzA} := I_{NAN,A} \star A_{yzN}$	cross sectional area yz of arc	macroscopic
72	$\hat{q}_{xA} := A_{yzA} \,.\, \_k^q_{xA} \,.\, (D_{N,A} \star T_N)$	heat flow in arc and x-direction	macroscopic

9 Interface Link Equation

no	equation	documentation	layer
22	$\_\lambda_S := \lambda_S$	interface equation	material –> macroscopic
60	$\_k^c_{xA} := k^c_{xA}$	interface equation	material –> macroscopic
61	$\_k^c_{yA} := k^c_{yA}$	interface equation	material –> macroscopic
62	$\_k^c_{zA} := k^c_{zA}$	interface equation	material –> macroscopic
63	$\_k^d_{xA,S} := k^d_{xA,S}$	interface equation	material –> macroscopic
64	${}_kd_{xF}ick_{A,S} := k^(d, Fick_{xA,S}$	interface equation	material –> macroscopic
65	${}_kd_{yF}ick_{A,S} := k^(d, Fick_{yA,S}$	interface equation	material –> macroscopic
66	$\_k^d_{yA,S} := k^d_{yA,S}$	interface equation	material –> macroscopic
67	$\_k^d_{zA,S} := k^d_{zA,S}$	interface equation	material –> macroscopic
68	${}_kd_{zF}ick_{A,S} := k^(d, Fick_{zA,S}$	interface equation	material –> macroscopic
69	$\_k^q_{xA} := k^q_{xA}$	interface equation	material –> macroscopic

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no	equation	documentation	layer
70	$\_k^q_{yA} := k^q_{yA}$	interface equation	material –> macroscopic
71	$\_k^q_{zA} := k^q_{zA}$	interface equation	material –> macroscopic