

# 1 Variables

## 2 root

	var	symbol	documentation	type	units	eqs
8	$F_{N,A}$	F_N_A	fudamental incidence matrix	network		
5	$t$	t	time	frame	s	
6	$t^o$	to	starting time	frame	s	4
7	$t^e$	te	end time	frame	s	5
1	#	value	numerical value	constant		
2	1	one	numerical value one	constant		1
3	0	zero	numerical value zero	constant		2
4	0.5	onehalf	numerical value one half	constant		3

### 3 physical

	var	symbol	documentation	type	units	eqs
9	$P_{N,A}$	P_N_A	projection from node to arc for arc properties	projection		
32	$P_{NS,AS}$	P_NS_AS	projection node species to arc species	projection		
33	$P_{K,NK}$	P_K_NK	projection of conversion to node conversion	projection		
34	$P_{S,NS}$	P_S_NS	projection species to node species	projection		
35	$P_{N,NK}$	P_N_NK	projection node to node conversion	projection		
36	$P_{NS,KS}$	P_NS_KS	projection node species to conversion species	projection		
37	$P_{A,NS}$	P_A_NS	projection arc to node species for conductivity	projection		
10	$r_{xN}$	r_x	x-coordinate	frame	$m$	
11	$r_{yN}$	r_y	y-coordinate	frame	$m$	
12	$r_{zN}$	r_z	z coordinate	frame	$m$	
13	$U_N$	U	fundamental state – internal energy	state	$kg\,m^2\,s^{-2}$	
14	$S_N$	S	fundamental state – entropy	state	$kg\,m^2\,K^{-1}\,s^{-2}$	
15	$V_N$	V	fundamental state – volume	state	$m^3$	
16	$n_{NS}$	n	fundamental state – molar mass	state	$mol$	
20	$H_N$	H	enthalpy	state	$kg\,m^2\,s^{-2}$	9
21	$A_N$	A	Helmholtz energy	state	$kg\,m^2\,s^{-2}$	10
22	$G_N$	G	Gibbs free energy	state	$kg\,m^2\,s^{-2}$	11
23	$C_N$	charge	fundamental state – charge	state	$A\,s$	
24	$A^v$	Avogadro	Avogadro number	constant	$mol^{-1}$	
25	$k^B_N$	Boltzmann	Boltzmann constant	constant	$kg\,m^2\,K^{-1}\,s^{-2}$	12
26	$R_N$	GasConstant	gas constant	constant	$kg\,m^2\,mol^{-1}\,K^{-1}\,s^{-2}$	13
17	$p_N$	p	thermodynamic pressure	effort	$kg\,m^{-1}\,s^{-2}$	6
18	$T_N$	T	temperature	effort	$K$	7

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	var	symbol	documentation	type	units	eqs
19	$\mu_{NS}$	<b>chemPot</b>	chemical potential	effort	$kg\,m^2\,mol^{-1}\,s^{-2}$	8
27	$U^C_N$	UC	electrical potential – voltage	effort	$kg\,m^2\,A^{-1}\,s^{-3}$	14
28	$v_{xN}$	<b>v_x</b>	velocity in x-direction	secondaryState	$ms^{-1}$	15
29	$v_{yN}$	<b>v_y</b>	velocity in y-direction	secondaryState	$ms^{-1}$	16
30	$v_{zN}$	<b>v_z</b>	velocity in z-direction	secondaryState	$ms^{-1}$	17

## 4 control

	var	symbol	documentation	type	units	eqs
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## 5 reactions

	var	symbol	documentation	type	units	eqs
31	$N_{S,K}$	<b>N</b>	stoichiometric matrix	constant		
38	$K^o_K$	<b>Ko</b>	Arrhenius frequency factor	constant	$m^{-3} mol s^{-1}$	
39	$E^a_{N,NK}$	<b>Ea</b>	Arrhenius activation energy	constant	$kg m^2 mol^{-1} s^{-2}$	<b>18 19</b>

## 6 material

	var	symbol	documentation	type	units	eqs
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## 7 macroscopic

	var	symbol	documentation	type	units	eqs
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## 8 solid

	var	symbol	documentation	type	units	eqs
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## 9 fluid

	var	symbol	documentation	type	units	eqs
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## 10 liquid

	var	symbol	documentation	type	units	eqs
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## 11 gas

	var	symbol	documentation	type	units	eqs
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## 12 control-control

	var	symbol	documentation	type	units	eqs
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## 13 gas–liquid

	var	symbol	documentation	type	units	eqs
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## 14 gas–gas

	var	symbol	documentation	type	units	eqs
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## 15 liquid–liquid

	var	symbol	documentation	type	units	eqs
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## 16 gas–solid

	var	symbol	documentation	type	units	eqs
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## 17 solid-solid

	var	symbol	documentation	type	units	eqs
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## 18 liquid–solid

	var	symbol	documentation	type	units	eqs
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## 19 material–material

	var	symbol	documentation	type	units	eqs
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## 20 reactions-reactions

	var	symbol	documentation	type	units	eqs
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## 21 control-reactions

	var	symbol	documentation	type	units	eqs
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## 22 reactions-control

	var	symbol	documentation	type	units	eqs
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## 23 control-material

	var	symbol	documentation	type	units	eqs
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## 24 material-control

	var	symbol	documentation	type	units	eqs
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## 25 control-macroscopic

	var	symbol	documentation	type	units	eqs
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## 26    macroscopic-control

	var	symbol	documentation	type	units	eqs
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## 27 reactions-material

	var	symbol	documentation	type	units	eqs
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## 28 material-reactions

	var	symbol	documentation	type	units	eqs
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## 29 reactions–macroscopic

	var	symbol	documentation	type	units	eqs
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## 30 macroscopic-reactions

	var	symbol	documentation	type	units	eqs
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## 31 material–macroscopic

	var	symbol	documentation	type	units	eqs
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## 32    macroscopic-material

	var	symbol	documentation	type	units	eqs
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### 33 Equations

### 34 Generic

no	equation	documentation	layer
1	$1 := \text{Instantiate}(\#, \#)$	numerical value 1	root
2	$0 := \text{Instantiate}(\#, \#)$	numerical value zero	root
3	$0.5 := \text{Instantiate}(\#, \#)$	numerical value one half	root
4	$t^o := \text{Instantiate}(t, \#)$	starting time	root
5	$t^e := \text{Instantiate}(t, \#)$	end time	root
6	$p_N := \left(-\frac{\partial U_N}{\partial V_N}\right)$	thermodynamic pressure	physical
7	$T_N := \frac{\partial U_N}{\partial S_N}$	temperature	physical
8	$\mu_{NS} := \frac{\partial U_N}{\partial n_{NS}}$	chemical potential	physical
9	$H_N := U_N - p_N \cdot V_N$	enthalpy	physical
10	$A_N := U_N - T_N \cdot S_N$	Helmholtz energy	physical
11	$G_N := U_N + p_N \cdot V_N - T_N \cdot S_N$	Gibbs free energy	physical
12	$k^B_N := \text{Instantiate}(S_N, \#)$	Boltzmann constant	physical
13	$R_N := A^v \cdot k^B_N$	gas constant	physical
14	$U^C_N := (C_N)^{-1} \cdot U_N$	electrical potential – voltage	physical
15	$v_{xN} := \frac{\partial r_{xN}}{\partial t}$	velocity in x-direction	physical
16	$v_{yN} := \frac{\partial r_{yN}}{\partial t}$	velocity in y direction	physical

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no	equation	documentation	layer
17	$v_{zN} := \frac{\partial r_{zN}}{\partial t}$	velocity in z-direction	physical
18	$E^a_{N,NK} := P_{N,NK} \stackrel{N}{\star} R_N . T_N$	Arrhenius activation energy	reactions
19	$E^a_{N,NK} := \text{Instantiate}(E^a_{N,NK}, \#)$	Arrhenius activation energy	reactions