Reduced Model of rat liver beta oxidation

```matlab
function [output] = liver_Karen_red(varargin)
time = varargin{1};
statevector = varargin{2};

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% STATES
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
C16AcylCarCYT = statevector(1);
C16AcylCarMAT = statevector(2);
C16AcylCoAMAT = statevector(3);
C16EnoylCoAMAT = statevector(4);
C14AcylCarCYT = statevector(5);
C14AcylCarMAT = statevector(6);
C14AcylCoAMAT = statevector(7);
C14EnoylCoAMAT = statevector(8);
C12AcylCarCYT = statevector(9);
C12AcylCarMAT = statevector(10);
C12AcylCoAMAT = statevector(11);
C12EnoylCoAMAT = statevector(12);
C10AcylCarCYT = statevector(13);
C10AcylCarMAT = statevector(14);
C10AcylCoAMAT = statevector(15);
C10EnoylCoAMAT = statevector(16);
C8Acyl1CarCYT = statevector(17);
C8Acyl1CarMAT = statevector(18);
C8AcylCoAMAT = statevector(19);
C8EnoylCoAMAT = statevector(20);
C6Acyl1CarCYT = statevector(21);
C6Acyl1CarMAT = statevector(22);
C6AcylCoAMAT = statevector(23);
C6EnoylCoAMAT = statevector(24);
C6KetoacylCoAMAT = statevector(25);
C4Acyl1CarCYT = statevector(26);
C4Acyl1CarMAT = statevector(27);
C4AcylCoAMAT = statevector(28);
C4EnoylCoAMAT = statevector(29);
AcetylCoAMAT = statevector(30);

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% PARAMETERS (Note that we have removed all the redundant parameters)
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
C16AcylCoACYT = 26.8*exp(-0.18*time);
Vcpt1 = 0.012;
Kmcpt1C16AcylCoACYT = 13.8;
Kmcpt1CarCYT = 125; %
Kmcpt1C16AcylCarCYT = 136;
Kmcpt1CoACYT = 40.7;
Kicpt1MalCoACYT = 9.1;
Keqcpt1 = 0.45;
ncpt1 = 2.4799;
Vfcact = 0.42;
```
\begin{verbatim}
KmcactC16AcylCarCYT = 15;
KmcactCarMAT = 130;
KicactC16AcylCarCYT = 56;
KicactCarCYT = 200;
sfcpt2C16 = 0.85;
sfcpt2C14 = 1;
sfcpt2C12 = 0.95;
sfcpt2C8 = 0.35;
sfcpt2C6 = 0.15;
sfcpt2C4 = 0.01;
Vcpt2 = 0.391;
Kmcpt2C16AcylCarMAT = 51;
Kmcpt2CoAMAT = 30;
Kmcpt2C16AcylCoAMAT = 38;
Kmcpt2C6AcylCoAMAT = 1000;
Kmcpt2C14AcylCoAMAT = 1000000;
Kmcpt2CarMAT = 350;
Keqcpt2 = 2.22;
sfvlicadC16 = 1;
sfvlicadC14 = 0.42;
sfvlicadC12 = 0.11;
Vvlcad = 0.008;
KmlcadC16AcylCoAMAT = 6.5;
KmlcadC14AcylCoAMAT = 4;
KmlcadC12AcylCoAMAT = 2.7;
KmlcadFAD = 0.12;
KmlcadEnoylCoAMAT = 1.08;
KmlcadFADH = 24.2;
Keqcad = 6;
sflcadC16 = 0.9;
sflcadC14 = 1;
sflcadC12 = 0.9;
sflcadC10 = 0.75;
Vlcad = 0.01;
KmlcadC16AcylCoAMAT = 2.5;
KmlcadC14AcylCoAMAT = 7.4;
KmlcadC12AcylCoAMAT = 9;
KmlcadC10AcylCoAMAT = 24.3;
KmlcadC8AcylCoAMAT = 123;
KmlcadFAD = 0.12;
KmlcadFADH = 24.2;
sfmcadC12 = 0.38;
sfmcadC10 = 0.8;
sfmcadC8 = 0.87;
sfmcadC6 = 1;
Vmcad = 0.081;
KmmcadC12AcylCoAMAT = 5.7;
KmmcadC10AcylCoAMAT = 5.4;
KmmcadC8AcylCoAMAT = 4;
KmmcadC6AcylCoAMAT = 9.4;
KmmcadC14AcylCoAMAT = 135;
KmmcadFAD = 0.12;
KmmcadFADH = 24.2;
sfscadC4 = 1;
Vscad = 0.081;
KmscadC6AcylCoAMAT = 285;
KmscadC4AcylCoAMAT = 10.7;
\end{verbatim}
KmscadFAD = 0.12;
KmscadFADH = 24.2;
sfcrotC6 = 0.83;
sfcrotC4 = 1;
Vcrot = 3.6;
KmcrotC6EnoylCoAMAT = 25;
KmcrotC4EnoylCoAMAT = 40;
KicrotC4AcetoacylCoA = 1.6;
Keqcrot = 3.13;
sfmschadC6 = 1;
sfmschadC4 = 0.67;
Vmschad = 1;
KmmschadC6HydroxyacylCoAMAT = 28.6;
KmmschadC4HydroxyacylCoAMAT = 69.9;
KmmschadNADMAT = 58.5;
KmmschadC6KetoacylCoAMAT = 5.8;
KmmschadC4KetoacylCoAMAT = 16.9;
KmmschadNADHMAT = 5.4;
Keqmschad = 2.17/10^4;
sfmckatC6 = 1;
sfmckatC4 = 0.49;
Vmckat = 0.377;
KmmckatC6KetoacylCoAMAT = 6.7;
KmmckatC4AcetoacylCoAMAT = 12.4;
KmmckatCoAMAT = 26.6;
KmmckatC4AcylCoAMAT = 13.83;
KmmckatAcetylCoAMAT = 30;
Keqmckat = 1051;
sfmsC16 = 1;
sfmsC14 = 0.9;
sfmsC12 = 0.81;
sfmsC10 = 0.73;
sfmsC8 = 0.34;
Vms = 2.84;
KmmsC16EnoylCoAMAT = 25;
KmmsNADMAT = 60;
KmmsCoAMAT = 30;
KmmsC16AcylCoAMAT = 13.83;
KmmsNADHMAT = 50;
KmmsAcetylCoAMAT = 30;
Keqmtp = 7138.4971/10^4;
CarCYT = 400;
CoACYT = 140;
MalCoACYT = 0;
CarMAT = 950;
FADtMAT = 0.77;
NADtMAT = 250;
CoAMATt = 5000;
VCYT = 0.01;
VMAT = 1.8/10^6;
Ksacesink = 6000000;
K1acesink = 30;
FADHMAT = 0.46;
NADHMAT = 16;
NAD = NADtMAT - NADHMAT;
\[ \text{CoAMAT} = \text{CoAMAT} - \text{C16AcylCoAMAT} - \text{C16EnoylCoAMAT} - \text{C14AcylCoAMAT} - \text{C14EnoylCoAMAT} - \text{C12AcylCoAMAT} - \text{C12EnoylCoAMAT} - \text{C10AcylCoAMAT} - \text{C10EnoylCoAMAT} - \text{C8AcylCoAMAT} - \text{C8EnoylCoAMAT} - \text{C6AcylCoAMAT} - \text{C6EnoylCoAMAT} - \text{C4AcylCoAMAT} - \text{C4AcetoacylCoAMAT} - \text{AcetylCoAMAT}; \]

\[ \text{vcpt1C16} = \text{CPT1}([\text{Vcpt1}, \text{Kmcpt1C16AcylCoACYT}, \text{Kmcpt1CarCYT}, \text{Kmcpt1C16AcylCarCYT}, \text{Kmcpt1Ma1CoACYT}, \text{Kmcpt1C16AcylCoACYT}, \text{CarCYT}, \text{C16AcylCarCYT}, \text{CoACYT}, \text{Ma1CoACYT}, \text{ncpt1}] ]; \]

\[ \text{vcactC16} = \text{CACT}([\text{Vfcact}, \text{KmcactC16AcylCarCYT}, \text{KmcactCarMAT}, \text{KicactCarCYT}, \text{C16AcylCarCYT}, \text{CarMAT}, \text{C16AcylCarMAT}, \text{CarCYT}]); \]

\[ \text{vcactC14} = \text{CACT}([\text{Vfcact}, \text{KmcactC16AcylCarCYT}, \text{KmcactCarMAT}, \text{KicactC16AcylCarCYT}, \text{CarMAT}, \text{C14AcylCarMAT}, \text{CarCYT}]); \]

\[ \text{vcactC12} = \text{CACT}([\text{Vfcact}, \text{KmcactC16AcylCarCYT}, \text{KmcactCarMAT}, \text{KicactC16AcylCarCYT}, \text{CarMAT}, \text{C12AcylCarMAT}, \text{CarCYT}]); \]

\[ \text{vcactC10} = \text{CACT}([\text{Vfcact}, \text{KmcactC16AcylCarCYT}, \text{KmcactCarMAT}, \text{KicactC16AcylCarCYT}, \text{CarMAT}, \text{C10AcylCarMAT}, \text{CarCYT}]); \]

\[ \text{vcactC8} = \text{CACT}([\text{Vfcact}, \text{KmcactC16AcylCarCYT}, \text{KmcactCarMAT}, \text{KicactC16AcylCarCYT}, \text{CarMAT}, \text{C8AcylCarMAT}, \text{CarCYT}]); \]

\[ \text{vcactC6} = \text{CACT}([\text{Vfcact}, \text{KmcactC16AcylCarCYT}, \text{KmcactCarMAT}, \text{KicactC16AcylCarCYT}, \text{CarMAT}, \text{C6AcylCarMAT}, \text{CarCYT}]); \]

\[ \text{vcactC4} = \text{CACT}([\text{Vfcact}, \text{KmcactC16AcylCarCYT}, \text{KmcactCarMAT}, \text{KicactC16AcylCarCYT}, \text{CarMAT}, \text{C4AcylCarMAT}, \text{CarCYT}]); \]

\[ \text{vcpt2C16} = \text{CPT2}([sfcpt2C16, \text{Vcpt2}, \text{Kmcpt2C16AcylCarMAT}, \text{Kmcpt2CoAMAT}, \text{Kmcpt2C16AcylCoAMAT}, \text{Kmcpt2C6AcylCoAMAT}, \text{Kmcpt2C4AcylCoAMAT}, \text{Kmcpt2CarMAT}, \text{Keqpt2}, \text{C16AcylCarMAT}, \text{C14AcylCarMAT}, \text{C12AcylCarMAT}, \text{C10AcylCarMAT}, \text{C8AcylCarMAT}, \text{CoAMAT}, \text{C16AcylCoAMAT}, \text{C14AcylCoAMAT}, \text{C12AcylCoAMAT}, \text{C10AcylCoAMAT}, \text{C8AcylCoAMAT}, \text{C6AcylCoAMAT}, \text{C4AcylCoAMAT}, \text{CarMAT}]); \]

\[ \text{vcpt2C14} = \text{CPT2}([sfcpt2C14, \text{Vcpt2}, \text{Kmcpt2C16AcylCarMAT}, \text{Kmcpt2CoAMAT}, \text{Kmcpt2C16AcylCoAMAT}, \text{Kmcpt2C6AcylCoAMAT}, \text{Kmcpt2C4AcylCoAMAT}, \text{Kmcpt2CarMAT}, \text{Keqpt2}, \text{C14AcylCarMAT}, \text{C16AcylCarMAT}, \text{C12AcylCarMAT}, \text{C10AcylCarMAT}, \text{C8AcylCarMAT}, \text{CoAMAT}, \text{C14AcylCoAMAT}, \text{C12AcylCoAMAT}, \text{C10AcylCoAMAT}, \text{C8AcylCoAMAT}, \text{C6AcylCoAMAT}, \text{C4AcylCoAMAT}, \text{CarMAT}]); \]

\[ \text{vcpt2C12} = \text{CPT2}([sfcpt2C12, \text{Vcpt2}, \text{Kmcpt2C16AcylCarMAT}, \text{Kmcpt2CoAMAT}, \text{Kmcpt2C16AcylCoAMAT}, \text{Kmcpt2C6AcylCoAMAT}, \text{Kmcpt2C4AcylCoAMAT}, \text{Kmcpt2CarMAT}, \text{Keqpt2}, \text{C12AcylCarMAT}, \text{C16AcylCarMAT}, \text{C14AcylCarMAT}, \text{C10AcylCarMAT}, \text{C8AcylCarMAT}, \text{CoAMAT}, \text{C12AcylCoAMAT}, \text{C10AcylCoAMAT}, \text{C8AcylCoAMAT}, \text{C6AcylCoAMAT}, \text{C4AcylCoAMAT}, \text{CarMAT}]); \]

\[ \text{vcpt2C10} = \text{CPT2}([sfcpt2C12, \text{Vcpt2}, \text{Kmcpt2C16AcylCarMAT}, \text{Kmcpt2CoAMAT}, \text{Kmcpt2C16AcylCoAMAT}, \text{Kmcpt2C6AcylCoAMAT}, \text{Kmcpt2C4AcylCoAMAT}, \text{Kmcpt2CarMAT}, \text{Keqpt2}, \text{C10AcylCarMAT}, \text{C16AcylCarMAT}, \text{C14AcylCarMAT}, \text{C12AcylCarMAT}, \text{C8AcylCarMAT}, \text{C6AcylCarMAT}, \text{C4AcylCarMAT}, \text{CoAMAT}, \text{C10AcylCoAMAT}, \text{C8AcylCoAMAT}, \text{C6AcylCoAMAT}, \text{C4AcylCoAMAT}, \text{CarMAT}]); \]
vcpt2C8 = CPT2([sfcpt2C8, Vcpt2, Kmcpt2C16AcylCarMAT, Kmcpt2CoAMAT, Kmcpt2C16AcylCoAMAT, Kmcpt2C14AcylCarMAT, Kmcpt2C12AcylCarMAT, Kmcpt2C10AcylCarMAT, Kmcpt2C8AcylCarMAT, Kmcpt2C6AcylCarMAT, Kmcpt2C4AcylCarMAT, Kmcpt2CarMAT, Keqcpt2, C8AcylCarMAT, C4AcylCarMAT, CarMAT]);
vcpt2C6 = CPT2([sfcpt2C6, Vcpt2, Kmcpt2C16AcylCarMAT, Kmcpt2CoAMAT, Kmcpt2C6AcylCoAMAT, Kmcpt2C16AcylCoAMAT, Kmcpt2C4AcylCoAMAT, Kmcpt2CarMAT, Keqcpt2, C6AcylCarMAT, C16AcylCarMAT, C14AcylCarMAT, C12AcylCarMAT, C8AcylCarMAT, C4AcylCarMAT, CarMAT]);
vcpt2C4 = CPT2([sfcpt2C4, Vcpt2, Kmcpt2C16AcylCarMAT, Kmcpt2CoAMAT, Kmcpt2C4AcylCoAMAT, Kmcpt2C16AcylCoAMAT, Kmcpt2C6AcylCoAMAT, Kmcpt2CarMAT, Keqcpt2, C4AcylCarMAT, C16AcylCarMAT, C14AcylCarMAT, C12AcylCarMAT, C8AcylCarMAT, C6AcylCarMAT, CarMAT]);
vvlcadC16 = VLCAD([sfvlcadC16, Vvlcad, KmvlcadC16AcylCoAMAT, KmvlcadC14AcylCoAMAT, KmvlcadC12AcylCoAMAT, KmvlcadC10AcylCoAMAT, KmvlcadC8AcylCoAMAT, KmvlcadC6AcylCoAMAT, KmvlcadC4AcylCoAMAT, KmvlcadFAD, KmvlcadFADH, Keqcad, C16AcylCoAMAT, C14AcylCoAMAT, C12AcylCoAMAT, C10AcylCoAMAT, C8AcylCoAMAT, C6AcylCoAMAT, C4AcylCoAMAT, FADtMAT, FADHtMAT, C16EnoylCoAMAT, C14EnoylCoAMAT, C12EnoylCoAMAT, C10EnoylCoAMAT, C8EnoylCoAMAT, C6EnoylCoAMAT, C4EnoylCoAMAT, FADHMAT]);
vvlcadC14 = VLCAD([sfvlcadC14, Vvlcad, KmvlcadC14AcylCoAMAT, KmvlcadC12AcylCoAMAT, KmvlcadC10AcylCoAMAT, KmvlcadC8AcylCoAMAT, KmvlcadC6AcylCoAMAT, KmvlcadC4AcylCoAMAT, KmvlcadFAD, KmvlcadFADH, Keqcad, C14AcylCoAMAT, C12AcylCoAMAT, C10AcylCoAMAT, C8AcylCoAMAT, C6AcylCoAMAT, C4AcylCoAMAT, FADtMAT, FADHtMAT, C14EnoylCoAMAT, C12EnoylCoAMAT, C10EnoylCoAMAT, C8EnoylCoAMAT, C6EnoylCoAMAT, C4EnoylCoAMAT, FADHMAT]);
vvlcadC12 = VLCAD([sfvlcadC12, Vvlcad, KmvlcadC12AcylCoAMAT, KmvlcadC10AcylCoAMAT, KmvlcadC8AcylCoAMAT, KmvlcadC6AcylCoAMAT, KmvlcadC4AcylCoAMAT, KmvlcadFAD, KmvlcadFADH, Keqcad, C12AcylCoAMAT, C10AcylCoAMAT, C8AcylCoAMAT, C6AcylCoAMAT, C4AcylCoAMAT, FADtMAT, FADHtMAT, C12EnoylCoAMAT, C10EnoylCoAMAT, C8EnoylCoAMAT, C6EnoylCoAMAT, C4EnoylCoAMAT, FADHMAT]);
vlcadC16 = LCAD([sfvlcad16, Vlcad, KmlcadC16AcylCoAMAT, KmlcadC14AcylCoAMAT, KmlcadC12AcylCoAMAT, KmlcadC10AcylCoAMAT, KmlcadC8AcylCoAMAT, KmlcadC6AcylCoAMAT, KmlcadFAD, KmlcadFADH, Keqcad, C16AcylCoAMAT, C14AcylCoAMAT, C12AcylCoAMAT, C10AcylCoAMAT, C8AcylCoAMAT, C6AcylCoAMAT, C4AcylCoAMAT, FADtMAT, FADHtMAT, C16EnoylCoAMAT, C14EnoylCoAMAT, C12EnoylCoAMAT, C10EnoylCoAMAT, C8EnoylCoAMAT, C6EnoylCoAMAT, C4EnoylCoAMAT, FADHMAT]);
vvlcadC14 = LCAD([sfvlcad14, Vlcad, KmlcadC14AcylCoAMAT, KmlcadC12AcylCoAMAT, KmlcadC10AcylCoAMAT, KmlcadC8AcylCoAMAT, KmlcadC6AcylCoAMAT, KmlcadC4AcylCoAMAT, KmlcadFAD, KmlcadFADH, Keqcad, C14AcylCoAMAT, C12AcylCoAMAT, C10AcylCoAMAT, C8AcylCoAMAT, C6AcylCoAMAT, C4AcylCoAMAT, FADtMAT, FADHtMAT, C14EnoylCoAMAT, C12EnoylCoAMAT, C10EnoylCoAMAT, C8EnoylCoAMAT, C6EnoylCoAMAT, C4EnoylCoAMAT, FADHMAT]);
vvlcadC12 = LCAD([sfvlcad12, Vlcad, KmlcadC12AcylCoAMAT, KmlcadC10AcylCoAMAT, KmlcadC8AcylCoAMAT, KmlcadC6AcylCoAMAT, KmlcadC4AcylCoAMAT, KmlcadFAD, KmlcadFADH, Keqcad, C12AcylCoAMAT, C10AcylCoAMAT, C8AcylCoAMAT, C6AcylCoAMAT, C4AcylCoAMAT, FADtMAT, FADHtMAT, C12EnoylCoAMAT, C10EnoylCoAMAT, C8EnoylCoAMAT, C6EnoylCoAMAT, C4EnoylCoAMAT, FADHMAT]);
vlcadC10 = LCAD([sfvlcad10, Vlcad, KmlcadC10AcylCoAMAT, KmlcadC8AcylCoAMAT, KmlcadC6AcylCoAMAT, KmlcadC4AcylCoAMAT, KmlcadFAD, KmlcadFADH, Keqcad, C10AcylCoAMAT, C8AcylCoAMAT, C6AcylCoAMAT, C4AcylCoAMAT, FADtMAT, FADHtMAT, C10EnoylCoAMAT, C8EnoylCoAMAT, C6EnoylCoAMAT, C4EnoylCoAMAT, FADHMAT]);
vlcadC8 = 0;
vmcadC12 = MCAD([sfmcad12, Vmcad, KmmcadC12AcylCoAMAT, KmmcadC10AcylCoAMAT, KmmcadC8AcylCoAMAT, KmmcadC6AcylCoAMAT, KmmcadC4AcylCoAMAT, KmmcadFAD, KmmcadFADH, Keqcad, C12AcylCoAMAT, C10AcylCoAMAT, C8AcylCoAMAT, C6AcylCoAMAT, C4AcylCoAMAT, FADtMAT, FADHtMAT, C12EnoylCoAMAT, C10EnoylCoAMAT, C8EnoylCoAMAT, C6EnoylCoAMAT, FADHMAT]);
vmcadC10 = MCAD([sfmcadC10, Vmcad, KmmcadC10AcylCoAMAT, KmmcadC6AcylCoAMAT, KmmcadC4AcylCoAMAT, KmmcadFAD, KmcadEnoylCoAMAT, KmmcadFADH, Keqcad, C10AcylCoAMAT, C12AcylCoAMAT, C8AcylCoAMAT, C6AcylCoAMAT, C4AcylCoAMAT, FADtMAT, C10EnoylCoAMAT, C6EnoylCoAMAT, C8EnoylCoAMAT, C12EnoylCoAMAT, C4EnoylCoAMAT, FADH2MAT]);
vmcadC8 = MCAD([sfmcadC8, Vmcad, KmmcadC8AcylCoAMAT, KmmcadC4AcylCoAMAT, KmmcadFAD, KmcadEnoylCoAMAT, KmmcadFADH, Keqcad, C8AcylCoAMAT, C12AcylCoAMAT, C10AcylCoAMAT, C4AcylCoAMAT, C6AcylCoAMAT, FADtMAT, C8EnoylCoAMAT, C12EnoylCoAMAT, C10EnoylCoAMAT, C4EnoylCoAMAT, FADH2MAT]);
vmmcadC6 = MCAD([sfmcadC6, Vmccd, KmmcadC6AcylCoAMAT, KmmcadC4AcylCoAMAT, KmmcadFAD, KmcadEnoylCoAMAT, KmmcadFADH, Keqcad, C6AcylCoAMAT, C12AcylCoAMAT, C10AcylCoAMAT, C4AcylCoAMAT, C8AcylCoAMAT, FADtMAT, C6EnoylCoAMAT, C12EnoylCoAMAT, C10EnoylCoAMAT, C4EnoylCoAMAT, FADH2MAT]);
vscadC4 = SCAD([sfscadC4, Vscad, KmscadC4AcylCoAMAT, KmscadFAD, KmscadFADH, Keqcad, C4AcylCoAMAT, C6AcylCoAMAT, C8AcylCoAMAT, C10AcylCoAMAT, C12AcylCoAMAT, FADtMAT, C4EnoylCoAMAT, C6EnoylCoAMAT, C8EnoylCoAMAT, C10EnoylCoAMAT]);
vcrmsC6 = CRMS([sfcrmsC6, Vcrms, KmcrotC6EnoylCoAMAT, KmcrotC4EnoylCoAMAT, KicrotC4AcetoacylCoA, Keqcrms, C6EnoylCoAMAT, C4EnoylCoAMAT, sfmschadC6, Vmschad, KmschadC6KetoacylCoAMAT, KmschadC4AcetoacylCoAMAT, KmschadNADMAT, Keqmschad, NAD, C6KetoacylCoAMAT, C4AcetoacylCoAMAT, C6KetoacylCoAMAT, NADH, C4AcetoacylCoAMAT]);
vmcktC6 = MCKATA([sfmcktC6, Vmckt, KmmcktC6KetoacylCoAMAT, KmmcktC4AcetoacylCoAMAT, KmmcktC6AcylCoAMAT, KmmcktC4AcylCoAMAT, KmmcktC4AcylCoAMAT, KmmcktC4AcylCoAMAT, C4AcylCoAMAT, C16AcylCoAMAT, C14AcylCoAMAT, C12AcylCoAMAT, C8AcylCoAMAT, C6AcylCoAMAT, AcetylCoAMAT]);
vmcktC4 = MCKATB([sfmcktC4, Vmckt, KmmcktC4AcetoacylCoAMAT, KmmcktC6KetoacylCoAMAT, KmmcktC4AcylCoAMAT, KmmcktC6AcylCoAMAT, KmmcktC4AcylCoAMAT, C4AcylCoAMAT, C16AcylCoAMAT, C14AcylCoAMAT, C12AcylCoAMAT, C8AcylCoAMAT, C6AcylCoAMAT, AcetylCoAMAT]);
vmtpc16 = MTP([sfmtpC16, Vmtp, Kmtpc16EnoylCoAMAT, KmtpNADMAT, KmtpoCoAMAT, Kmtpc16AcylCoAMAT, KmtpNADH, KmtpAcetylCoAMAT, Keqmpc, C16EnoylCoAMAT, C14EnoylCoAMAT, C10EnoylCoAMAT, C8EnoylCoAMAT, C12EnoylCoAMAT, C16AcylCoAMAT, C12AcylCoAMAT, C10AcylCoAMAT, C8AcylCoAMAT, C6AcylCoAMAT, AcetylCoAMAT]);
vmtpc14 = MTP([sfmtpC14, Vmtp, Kmtpc14EnoylCoAMAT, KmtpNADMAT, KmtpoCoAMAT, Kmtpc16AcylCoAMAT, KmtpNADH, KmtpAcetylCoAMAT, Keqmpc, C14EnoylCoAMAT, C16EnoylCoAMAT, C10EnoylCoAMAT, C8EnoylCoAMAT, C12EnoylCoAMAT, C16AcylCoAMAT, C12AcylCoAMAT, C10AcylCoAMAT, C8AcylCoAMAT, C6AcylCoAMAT, AcetylCoAMAT]);
vmtpc12 = MTP([sfmtpC12, Vmtp, Kmtpc14EnoylCoAMAT, KmtpNADMAT, KmtpoCoAMAT, Kmtpc16AcylCoAMAT, KmtpNADH, KmtpAcetylCoAMAT, Keqmpc, C12EnoylCoAMAT, C16EnoylCoAMAT, C10EnoylCoAMAT, C8EnoylCoAMAT, C12EnoylCoAMAT, C16AcylCoAMAT, C12AcylCoAMAT, C10AcylCoAMAT, C8AcylCoAMAT, C6AcylCoAMAT, AcetylCoAMAT]);
vmtpc10 = MTP([sfmtpC10, Vmtp, Kmtpc14EnoylCoAMAT, KmtpNADMAT, KmtpoCoAMAT, Kmtpc16AcylCoAMAT, KmtpNADH, KmtpAcetylCoAMAT, Keqmpc, C10EnoylCoAMAT,
C16EnoylCoAMAT, C14EnoylCoAMAT, C12EnoylCoAMAT, C8EnoylCoAMAT, NADtMAT, CoAMAT, C8AcylCoAMAT, C16AcylCoAMAT, C14AcylCoAMAT, C12AcylCoAMAT, C10AcylCoAMAT, C6AcylCoAMAT, C8AcylCoAMAT, C16AcylCoAMAT, C14AcylCoAMAT, C10AcylCoAMAT, C8AcylCoAMAT, NADHMAT, AcetylCoAMAT); 
vmtpC8  = MTP([sfmtpC8, Vmtp, KmmtpC16EnoylCoAMAT, KmmtpNADMAT, KmmtpCoAMAT, KmmtpC16AcylCoAMAT, KmmtpNADHMAT, Keqmtp, C8EnoylCoAMAT, C16EnoylCoAMAT, C14EnoylCoAMAT, C12EnoylCoAMAT, NADtMAT, C16AcylCoAMAT, C14AcylCoAMAT, C12AcylCoAMAT, C10AcylCoAMAT, C8AcylCoAMAT, NADHMAT, AcetylCoAMAT]); 

vacesink = RES([Ksacesink, AcetylCoAMAT, K1acesink]); 

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% DIFFERENTIAL EQUATIONS
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
output(1) = (vcpt1C16 - vcactC16)/VCYT;
output(2) = (vcactC16 - vcpt2C16)/VMAT;
output(3) = (vcpt2C16 - vvlcadC16 - vlcadC16)/VMAT;
output(4) = (vvlcadC16 + vlcadC16 - vmtpC16)/VMAT;
output(5) = - vcactC14/VCYT;
output(6) = (vcactC14 - vcpt2C14)/VMAT;
output(7) = (vcpt2C14 + vvlcadC14 - vlcadC14)/VMAT;
output(8) = (vvlcadC14 + vlcadC14 - vmtpC14)/VMAT;
output(9) = - vcactC12/VCYT;
output(10) = (vcactC12 - vcpt2C12)/VMAT;
output(11) = (vcpt2C12 + vvlcadC12 - vlcadC12 - vmcadC12)/VMAT;
output(12) = (vvlcadC12 + vlcadC12 + vmcadC12 - vmtpC12)/VMAT;
output(13) = - vcactC10/VCYT;
output(14) = (vcactC10 - vcpt2C10)/VMAT;
output(15) = (vcpt2C10 + vvlcadC10 - vlcadC10 - vmcadC10)/VMAT;
output(16) = (vlcadC10 + vmcadC10 - vmtpC10)/VMAT;
output(17) = - vcactC8/VCYT;
output(18) = (vcactC8 - vcpt2C8)/VMAT;
output(19) = (vcpt2C8 + vvlcadC8 - vlcadC8 - vmcadC8)/VMAT;
output(20) = (vlcadC8 + vmcadC8 - vmtpC8)/VMAT;
output(21) = - vcactC6/VCYT;
output(22) = (vcactC6 - vcpt2C6)/VMAT;
output(23) = (vcpt2C6 + vvlcadC6 - vlcadC6 - vmcdC6)/VMAT;
output(24) = (vmcadC6 - vcrmsC6)/VMAT;
output(25) = (vcrmsC6 - vmckatC6)/VMAT;
output(26) = - vcactC4/VCYT;
output(27) = (vcactC4 - vcpt2C4)/VMAT;
output(28) = (vcpt2C4 + vmckatC6 - vscaC4)/VMAT;
output(29) = (vscaC4 - vcrmsC4)/VMAT;
output(30) = (vcrmsC4 - vmckatC4)/VMAT;
output(31) = (1/VMAT)*(vmtpC16 + vmtpC14 + vmtpC12 + vmtpC10 + vmtpC8 + vmckatC6 + 2*vmckatC4 - vacesink);

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% RETURN VALUES
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% return a column vector
output = output(:);
%end;

function output = CPT1(input)
V = input(1);
Kms1 = input(2);
Kms2 = input(3);
Kmp1 = input(4);
Kmp2 = input(5);
Ki1 = input(6);
Keq = input(7);
S1 = input(8);
S2 = input(9);
P1 = input(10);
P2 = input(11);
I1 = input(12);
n = input(13);

output = (V*((S1*S2)/(Kms1*Kms2) - (P1*P2)/(Kms1*Kms2*Keq)))/((1 + S1/Kms1 + P1/Kmp1 + (I1/Ki1)^n)*(1 + S2/Kms2 + P2/Kmp2));
%end;

function output = CACT(input)

Vf = input(1);
Kms1 = input(2);
Kms2 = input(3);
Kis1 = input(4);
Kip2 = input(5);
S1 = input(6);
S2 = input(7);
P1 = input(8);
P2 = input(9);

output = Vf*(S1*S2 - P1*P2)/(S1*S2 + Kms2*S1 + Kms1*S2*(1 + P2/Kip2) + Kms2*P1*(1 + S1/Kis1) + P2*(Kms1 + P1));
%end;

function output = CPT2(input)

sf = input(1);
V = input(2);
Kms1 = input(3);
Kms8 = input(4);
Kmp1 = input(5);
Kmp2 = input(6);
Kmp6 = input(7);
Kmp7 = input(8);
Kmp8 = input(9);
Keq = input(10);
S1 = input(11);
S2 = input(12);
S3 = input(13);
S4 = input(14);
S5 = input(15);
S6 = input(16);
S7 = input(17);
S8 = input(18);
P1 = input(19);
P2 = input(20);
P3 = input(21);
P4 = input(22);
P5 = input(23);
P6 = input(24);
P7 = input(25);
P8 = input(26);
output = (sf*V*((S1*S8)/(Kms1*Kms8) - (P1*P8)/(Kms1*Kms8*Keq)))/((1 + S1/Kms1 + P1/Kmp1 + S2/Kms1 + P2/Kmp2 + S3/Kms1 + P3/Kmp2 + S4/Kms1 + P4/Kmp2 + S5/Kms1 + P5/Kmp2 + S6/Kms1 + P6/Kmp6 + S7/Kms1 + P7/Kmp7)*(1 + S8/Kms8 + P8/Kmp8));
end;

function output = VLCAD(input)

sf = input(1);
V = input(2);
Kms1 = input(3);
Kms2 = input(4);
Kms3 = input(5);
Kms4 = input(6);
Kmp1 = input(7);
Kmp4 = input(8);
Keq = input(9);
S1 = input(10);
S2 = input(11);
S3 = input(12);
S4 = input(13);
P1 = input(14);
P2 = input(15);
P3 = input(16);
P4 = input(17);

output = (sf*V*((S1*(S4 - P4))/(Kms1*Kms4) - (P1*P4)/(Kms1*Kms4*Keq)))/((1 + S1/Kms1 + P1/Kmp1 + S2/Kms2 + P2/Kmp1 + S3/Kms3 + P3/Kmp1)*(1 + (S4 - P4)/Kms4 + P4/Kmp4));
end;

function output = LCAD(input)

sf = input(1);
V = input(2);
Kms1 = input(3);
Kms2 = input(4);
Kms3 = input(5);
Kms4 = input(6);
Kms5 = input(7);
Kms6 = input(8);
Kmp1 = input(9);
Kmp6 = input(10);
Keq = input(11);
S1 = input(12);
S2 = input(13);
S3 = input(14);
S4 = input(15);
S5 = input(16);
S6 = input(17);
P1 = input(18);
P2 = input(19);
P3 = input(20);
P4 = input(21);
P5 = input(22);
P6 = input(23);

output = (sf*V*{(S1*(S6 - P6))/(Kms1*Kms6) - (P1*P6)/(Kms1*Kms6*Keq)})/((1 + S1/Kms1 + P1/Kmp1 + S2/Kms2 + P2/Kmp1 + S3/Kms3 + P3/Kmp1 + S4/Kms4 + P4/Kmp1 + S5/Kms5 + P5/Kmp1)*(1 + (S6 - P6)/Kms6 + P6/Kmp6));

function output = MCAD(input)

sf = input(1);
V = input(2);
Kms1 = input(3);
Kms2 = input(4);
Kms3 = input(5);
Kms4 = input(6);
Kms5 = input(7);
Kms6 = input(8);
Kmp1 = input(9);
Kmp6 = input(10);
Keq = input(11);
S1 = input(12);
S2 = input(13);
S3 = input(14);
S4 = input(15);
S5 = input(16);
S6 = input(17);
P1 = input(18);
P2 = input(19);
P3 = input(20);
P4 = input(21);
P5 = input(22);
P6 = input(23);

output = (sf*V*{(S1*(S6 - P6))/(Kms1*Kms6) - (P1*P6)/(Kms1*Kms6*Keq)})/((1 + S1/Kms1 + P1/Kmp1 + S2/Kms2 + P2/Kmp1 + S3/Kms3 + P3/Kmp1 + S4/Kms4 + P4/Kmp1 + S5/Kms5 + P5/Kmp1)*(1 + (S6 - P6)/Kms6 + P6/Kmp6));

function output = SCAD(input)

sf = input(1);
V = input(2);
Kms1 = input(3);
Kms2 = input(4);
Kms3 = input(5);
Kmp1 = input(6);
Kmp3 = input(7);
Keq = input(8);
S1 = input(9);
S2 = input(10);
S3 = input(11);
P1 = input(12);
P2 = input(13);
P3 = input(14);

output = (sf*V*((S1*(S3 - P3))/(Kms1*Kms3) - (P1*P3)/(Kms1*Kms3*Keq)))/((1 + S1/Kms1 + P1/Kmp1 + S2/Kms2 + P2/Kmp1)*(1 + (S3 - P3)/Kms3 + P3/Kmp3));
%end;

function output = CRMS(input)

sfc = input(1);
Vc = input(2);
Kms1 = input(3);
Kms2 = input(4);
K1 = input(5);
Keqc = input(6);
S1 = input(7);
S2 = input(8);
sfm = input(9);
Vm = input(10);
Kmms1 = input(11);
Kmp0 = input(12);
Kmp1 = input(13);
Kmp2 = input(14);
Kmp3 = input(15);
Keqm = input(16);
P0 = input(17);
P1 = input(18);
P2 = input(19);
P3 = input(20);
I1 = input(21);

output = (sfc*Vc*sfm*Vm*((S1*P0)/(Kms1*Kmms1*Kmp0) - (P1*P3)/(Kms1*Kmms1*Kmp0*Keqc*Keqm)))/(sfc*Vc*(1 + P1/Kmp1 + P2/Kmp2)*(1 + P0/Kmp0 + P3/Kmp3)/(Kms1*Keqc)+sfm*Vm*P0*(1 + S1/Kms1 + S2/Kms2 + I1/K1)/(Kmms1*Kmp0));
%end;

function output = MCKATA(input)

sf = input(1);
V = input(2);
Kms1 = input(3);
Kms2 = input(4);
Kms8 = input(5);
Kmp1 = input(6);
Kmp8 = input(7);
Keq = input(8);
S1 = input(9);
S2 = input(10);
S8 = input(11);
P1 = input(12);
P2 = input(13);
P3 = input(14);
P4 = input(15);
P5 = input(16);
P6 = input(17);
P7 = input(18);
P8 = input(19);

output = (sf*V*((S1*S8)/(Kms1*Kms8) - (P1*P8)/(Kms1*Kms8*Keq)))/{(1 + S1/Kms1 + P1/Kmp1 + S2/Kms2 + P2/Kmp1 + P3/Kmp1 + P4/Kmp1 + P5/Kmp1 + P6/Kmp1 + P7/Kmp1 + P8/Kmp8)*(1 + S8/Kms8 + P8/Kmp8));
%end;

function output = MCKATB(input)

sf = input(1);
V = input(2);
Kms1 = input(3);
Kms2 = input(4);
Kms8 = input(5);
Kmp1 = input(6);
Kmp8 = input(7);
Keq = input(8);
S1 = input(9);
S2 = input(10);
S8 = input(11);
P1 = input(12);
P2 = input(13);
P3 = input(14);
P4 = input(15);
P5 = input(16);
P6 = input(17);
P7 = input(18);
P8 = input(19);

output = (sf*V*((S1*S8)/(Kms1*Kms8) - (P8*P8)/(Kms1*Kms8*Keq)))/{(1 + S1/Kms1 + P1/Kmp1 + S2/Kms2 + P2/Kmp1 + P3/Kmp1 + P4/Kmp1 + P5/Kmp1 + P6/Kmp1 + P7/Kmp1 + P8/Kmp8)*(1 + S8/Kms8 + P8/Kmp8));
%end;

function output = MTP(input)

sf = input(1);
V = input(2);
Kms1 = input(3);
Kms7 = input(4);
Kms8 = input(5);
Kmp1 = input(6);
Kmp7 = input(7);
Kmp8 = input(8);
Keq = input(9);
S1 = input(10);
S3 = input(11);
S4 = input(12);
S5 = input(13);
S7 = input(15);
S8 = input(16);
P1 = input(17);
P2 = input(18);
P3 = input(19);
P4 = input(20);
P5 = input(21);
P6 = input(22);
P7 = input(23);
P8 = input(24);

output = (sf*V*((S1*(S7 - P7)*S8)/(Kms1*Kms7*Kms8) -
(P1*P7*P8)/(Kms1*Kms7*Kms8*Keq)))/(1 + S1/Kms1 + P1/Kmp1 + S2/Kms1 + P2/Kmp1
+ S3/Kms1 + P3/Kmp1 + S4/Kms1 + P4/Kmp1 + S5/Kms1 + P5/Kmp1 + P6/Kmp1)*(1 +
(S7 - P7)/Kms7 + P7/Kmp7)*(1 + S8/Kms8 + P8/Kmp8));

function output = RES(input)

Ks = input(1);
S = input(2);
K1 = input(3);

output = Ks*(S - K1);
%end;