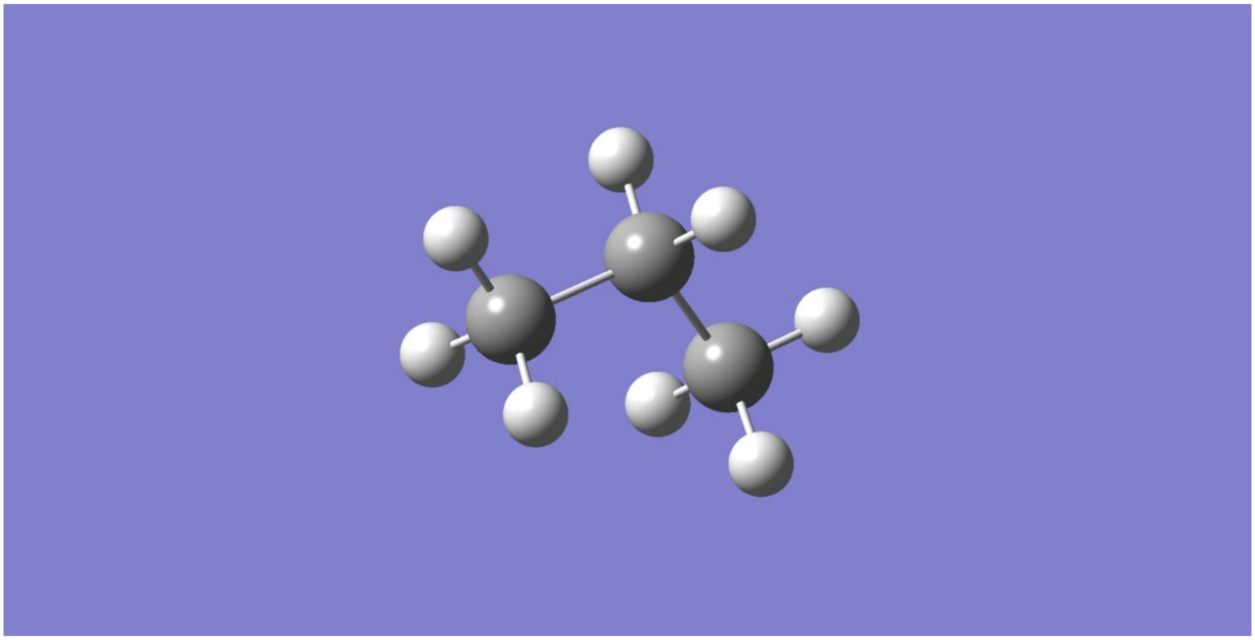
Guilherme Bertola

Final Exam

I used gaussian to optimize the molecules described in the problem given for the final exam, each of the molecule's results are shown below with their thermochemistry results:

C3H8



- Thermochemistry -

Zero-point correction= 0.104122 (Hartree/Particle)

Thermal correction to Energy= 0.108635

Thermal correction to Enthalpy= 0.109580

Thermal correction to Gibbs Free Energy= 0.079118

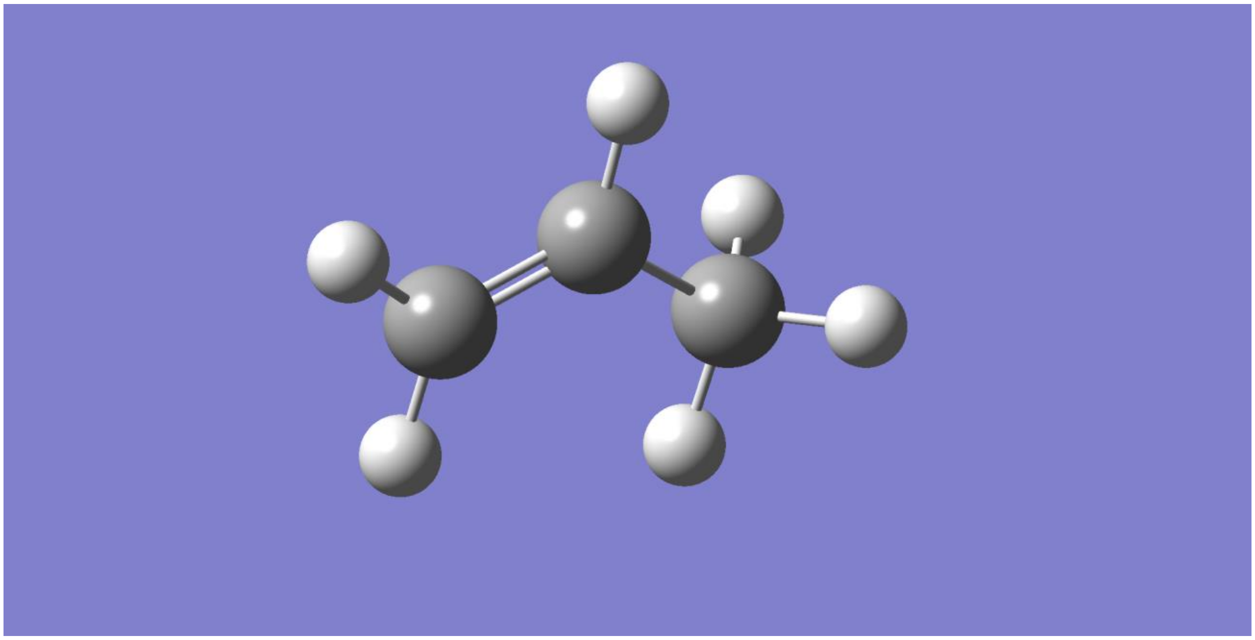
Sum of electronic and zero-point Energies= -119.040127

Sum of electronic and thermal Energies= -119.035613

Sum of electronic and thermal Enthalpies= -119.034669

Sum of electronic and thermal Free Energies= -119.065131

C3H6



- Thermochemistry -

Zero-point correction= 0.080082 (Hartree/Particle)

Thermal correction to Energy= 0.084158

Thermal correction to Enthalpy= 0.085102

Thermal correction to Gibbs Free Energy= 0.055079

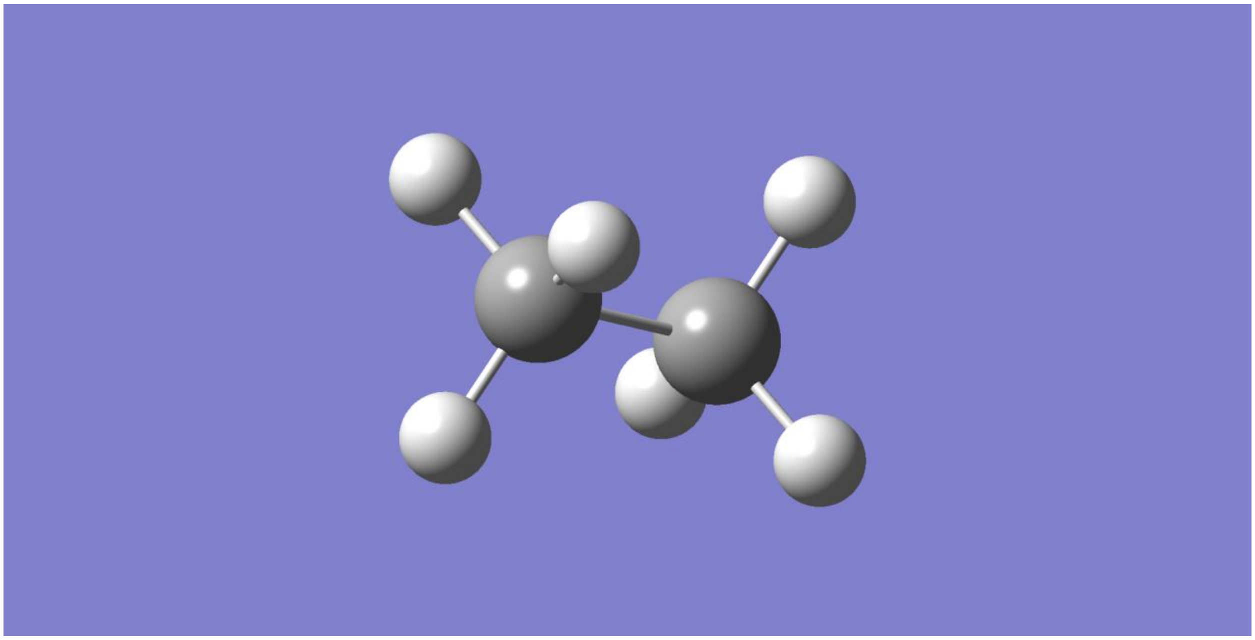
Sum of electronic and zero-point Energies= -117.827475

Sum of electronic and thermal Energies= -117.823398

Sum of electronic and thermal Enthalpies= -117.822454

Sum of electronic and thermal Free Energies= -117.852477

C2H6



- Thermochemistry -

Zero-point correction= 0.075229 (Hartree/Particle)

Thermal correction to Energy= 0.078698

Thermal correction to Enthalpy= 0.079642

Thermal correction to Gibbs Free Energy= 0.053810

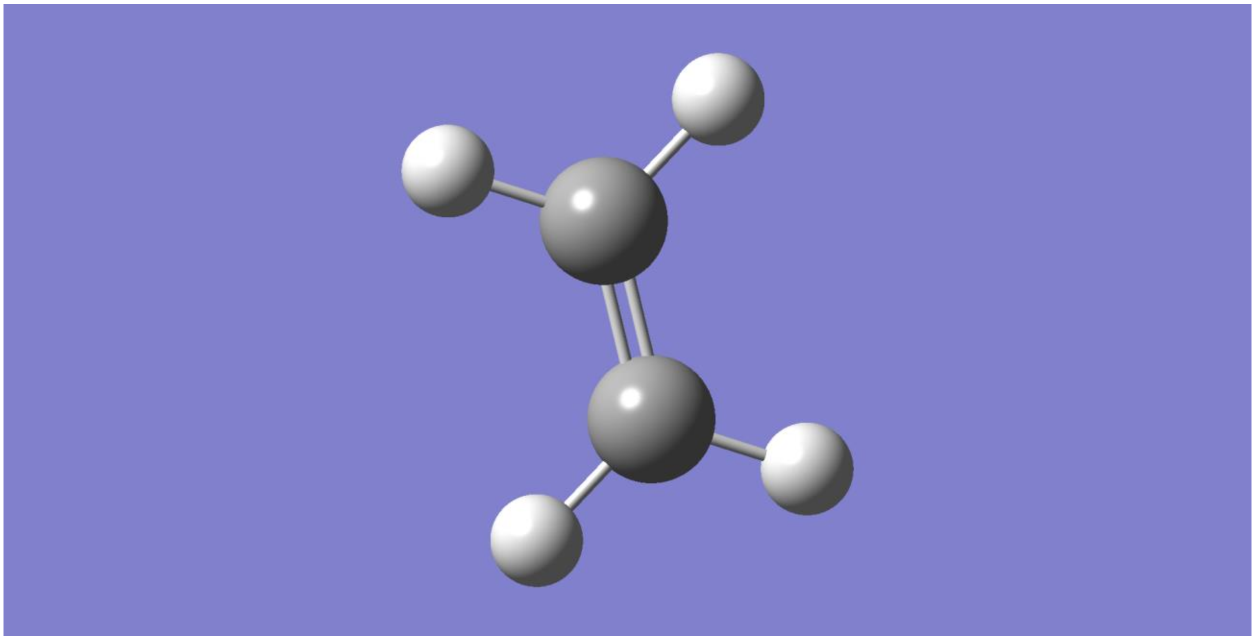
Sum of electronic and zero-point Energies= -79.755188

Sum of electronic and thermal Energies= -79.751720

Sum of electronic and thermal Enthalpies= -79.750776

Sum of electronic and thermal Free Energies= -79.776607

C2H4



- Thermochemistry -

Zero-point correction= 0.050845 (Hartree/Particle)

Thermal correction to Energy= 0.053888

Thermal correction to Enthalpy= 0.054832

Thermal correction to Gibbs Free Energy= 0.029321

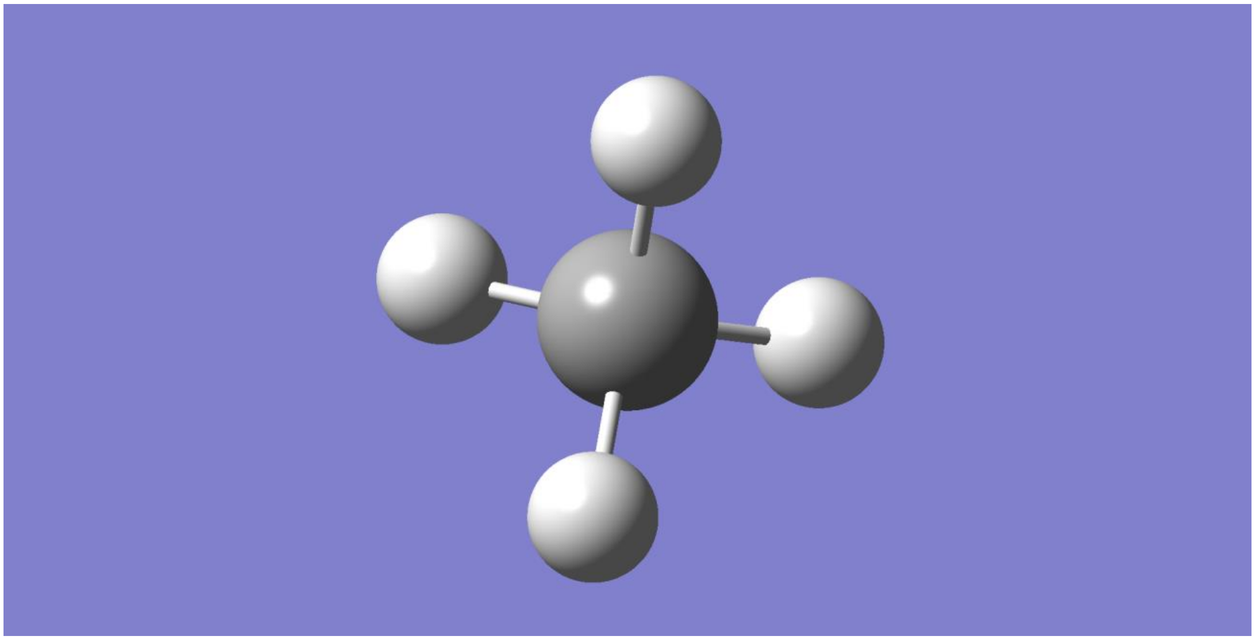
Sum of electronic and zero-point Energies= -78.556112

Sum of electronic and thermal Energies= -78.553069

Sum of electronic and thermal Enthalpies= -78.552125

Sum of electronic and thermal Free Energies= -78.577636

CH4



- Thermochemistry -

Zero-point correction= 0.045214 (Hartree/Particle)

Thermal correction to Energy= 0.048078

Thermal correction to Enthalpy= 0.049022

Thermal correction to Gibbs Free Energy= 0.027890

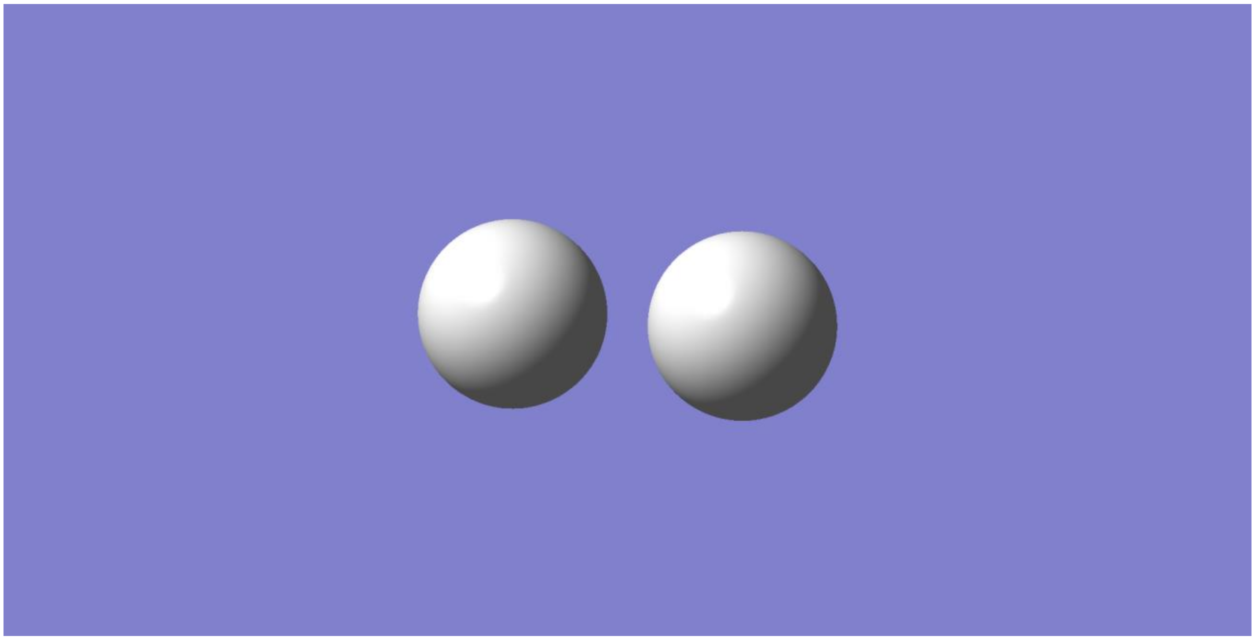
Sum of electronic and zero-point Energies= -40.473175

Sum of electronic and thermal Energies= -40.470311

Sum of electronic and thermal Enthalpies= -40.469367

Sum of electronic and thermal Free Energies= -40.490499

H2



- Thermochemistry -

Zero-point correction= 0.010145 (Hartree/Particle)

Thermal correction to Energy= 0.012505

Thermal correction to Enthalpy= 0.013450

Thermal correction to Gibbs Free Energy= -0.001342

Sum of electronic and zero-point Energies= -1.165337

Sum of electronic and thermal Energies= -1.162977

Sum of electronic and thermal Enthalpies= -1.162033

Sum of electronic and thermal Free Energies= -1.176825

MATLAB CODE:

```
%Final Exam%
%Guilherme Bertola%

% C3H8 -> 0.3 C3H6 + 0.065 C2H6 + 0.6675 C2H4 + 0.635 CH4 + 0.3 H2
% A -> 0.3 B + 0.065 C + 0.6675 D + 0.635 E + 0.3 F

%Letter | Molecule
%  A    |   C3H8
%  B    |   C3H6
%  C    |   C2H6
%  D    |   C2H4
%  E    |   CH4
%  F    |   H2

%stoic table
% Species | Fi0  | Exit (Fi) |     Exit (Ci)      |
%---------|------|-----------|--------------------|
% A       |  F0  |    F0 - z |   F0-F0*Xa / v     |
% B       |   0  |    0.3z   |   0.3*F0*Xa / v    |
% C       |   0  |    0.065z | 0.065*F0*Xa / v    |
% D       |   0  |    0.6675z| 0.6675*F0*Xa / v   |
% E       |   0  |    0.653z | 0.635*F0*Xa / v    |
% F       |   0  |    0.3z   |   0.3*F0*Xa / v    |
%---------|------|-----------|--------------------|
% Total   |  F0  |    Ft     |  F0-0.9855*F0*Xa/v|

% Fa0 = F0
% Fa = F0 - F0*Xa
% Fa = F0 - z
% then
% z = F0*Xa (extent of reaction)

%stoic indexes
vA = 1;
vB = 0.3;
vC = 0.065;
vD = 0.6675;
vE = 0.635;
vF = 0.3;

%known parameters
%conversion
Xa = 0.8;
%Initial Temperature
T0 = 1100; %F
T0 = (T0-32) * 5/9 + 273.15; %K
%Inital Pressure
P0 = 60;% psia
```

```
P0 = P0 * 6894.76; %Pa
%molar mass of propane
Ma = 44.097;%g/mol
Ma = Ma/1000; %kg/mol
%Feed Rate (mass)
M0 = 7000;% lb/h
M0 = M0/2.205; %Kg/h
M0 = M0/3600; %Kg/s
%Feed Rate (mol)
F0 = M0/Ma; %mol/s
%R gas constant
R = 8.31446261815324; %m3?Pa?K?1?mol?1
%concentration
c = P0/(R*T0); %mol/m3
%volumetric flow
v0 = F0/c; %m3/s
%Heat flux
Q = 2.52e6; %cal/(h*ft2)
Q = Q*10.764; %cal/(h*m2)
Q = Q/3600; %cal/(s*m2)

%pipes data
%2 inch diameter pipe
di_2 = 2.07; %in        Internal diameter
ai_2 = 3.36; %in2       Internal Transverse Area
do_2 = 2.375; %in       External Diameter
wpft_2 = 3.65; %lb/ft   Weight per length
di_2 = di_2 / 39.37;%m
do_2 = do_2 / 39.37;%m
ai_2 = ai_2 / 1550;%m2
ff_2 = 0.0050;%         Friction factor
%4 inch diameter pipe
di_4 = 4.03; %in        Internal diameter
ai_4 = 12.73;%in2       Internal Transverse Area
do_4 = 4.500; %in       External Diameter
wpft_4 = 10.79;%lb/ft   Weight per length
di_4 = di_4 / 39.37;%m
do_4 = do_4 / 39.37;%m
ai_4 = ai_4 / 1550;%m2
ff_4 = 0.0044;%         Friction factor
%6 inch diameter pipe
di_6 = 6.07; %in        Internal diameter
ai_6 = 28.89;%in2       Internal Transverse Area
do_6 = 6.625; %in       External Diameter
wpft_6 = 18.97;%lb/ft   Weight per length
di_6 = di_6 / 39.37;%m
do_6 = do_6 / 39.37;%m
ai_6 = ai_6 / 1550;%m2
ff_6 = 0.0044;%         Friction factor

%heats of reactions
%gaussian calculated (298 K)
```

```
dH_H2_gau = -1.162033; %Hartrees
dH_CH4_gau = -40.469367; %hartrees
dH_C3H8_gau = -119.034669; %hartrees
dH_C3H6_gau = -117.822454; %hartrees
dH_C2H6_gau = -79.750776; %hartress
dH_C2H4_gau = -78.552125; %hartress

dH_prod = vB*dH_C3H6_gau + vC*dH_C2H6_gau + vD*dH_C2H4_gau +
vE*dH_CH4_gau + vF*dH_H2_gau; %hartrees
dH_reac = vA*dH_C3H8_gau; %hartrees

dH_Gau_298 = dH_prod - dH_reac; %hartrees
dH_Gau_298 = dH_Gau_298 * 627.5095; %Kcal/mol
dH_Gau_298 = dH_Gau_298 * 1000; %cal/mols

%length of the reactor (m)
len_span = linspace(0,426,400); %426 m ~ 1400 ft

%initial conditions
y0 = [F0,0,0,0,0,0,T0,P0];

%RUNS%
%Gaussian dH
%2 in
Tr = 298; %K
dH_ref = dH_Gau_298; %cal/mol
%Pipe data:
A = ai_2;
D = di_2;
DO = do_2;
ff = ff_2;
%ODE run
[l,x] =
ode15s(@(L,x)PFR(L,x,T0,P0,F0,M0,v0,Q,Tr,dH_ref,A,ff,D,DO),len_span,y0
);
T_2_in = x(:,7); %K
P_2_in = x(:,8); %Pa
P_2_in = P_2_in./6895;%psia
Fa_2_in = x(:,1);%mol/s
Xa_2_in = (F0-Fa_2_in)./F0;
Xa_2_in = Xa_2_in*100; % (%)
L_2_in = l * 3.281; % ft
%Plots
figure;
subplot(2,2,1);
plot(L_2_in,T_2_in);
title("Temperature vs Length");
xlabel("Length (ft)");
ylabel("Temperature (K)");
subplot(2,2,2);
plot(L_2_in,P_2_in);
title("Pressure vs Length");
```

```
xlabel("Length (ft)");
ylabel("Pressure (psia)");
subplot(2,2,[3,4]);
plot(L_2_in,Xa_2_in);
title("Conversion vs Length");
xlabel("Length (ft)");
ylabel("Conversion (%)");
sgtitle("2 inches diameter pipe");

%4 in
Tr = 298; %K
dH_ref = dH_Gau_298; %cal/mol
%Pipe data:
A = ai_4;
D = di_4;
DO = do_4;
ff = ff_4;
%ODE run
[l,x] =
ode15s(@(L,x)PFR(L,x,T0,P0,F0,M0,v0,Q,Tr,dH_ref,A,ff,D,DO),len_span,y0
);
T_4_in = x(:,7); %K
P_4_in = x(:,8); %Pa
P_4_in = P_4_in./6895;%psia
Fa_4_in = x(:,1);%mol/s
Xa_4_in = (F0-Fa_4_in)./F0;
Xa_4_in = Xa_4_in*100; % (%)
L_4_in = l * 3.281; % ft
%Plots
figure;
subplot(2,2,1);
plot(L_4_in,T_4_in);
title("Temperature vs Length");
xlabel("Length (ft)");
ylabel("Temperature (K)");
subplot(2,2,2);
plot(L_4_in,P_4_in);
title("Pressure vs Length");
xlabel("Length (ft)");
ylabel("Pressure (psia)");
subplot(2,2,[3,4]);
plot(L_4_in,Xa_4_in);
title("Conversion vs Length");
xlabel("Length (ft)");
ylabel("Conversion (%)");
sgtitle("4 inches diameter pipe");

%6 in
Tr = 298; %K
dH_ref = dH_Gau_298; %cal/mol
%Pipe data:
A = ai_6;
```

```
D = di_6;
DO = do_6;
ff = ff_6;
%ODE run
[l,x] =
ode15s(@(L,x)PFR(L,x,T0,P0,F0,M0,v0,Q,Tr,dH_ref,A,ff,D,DO),len_span,y0
);
T_6_in = x(:,7); %K
P_6_in = x(:,8); %Pa
P_6_in = P_6_in./6895;%psia
Fa_6_in = x(:,1);%mol/s
Xa_6_in = (F0-Fa_6_in)./F0;
Xa_6_in = Xa_6_in*100; % (%)
L_6_in = l * 3.281; %ft
%Plots
figure;
subplot(2,2,1);
plot(L_6_in,T_6_in);
title("Temperature vs Length");
xlabel("Length (ft)");
ylabel("Temperature (K)");
subplot(2,2,2);
plot(L_6_in,P_6_in);
title("Pressure vs Length");
xlabel("Length (ft)");
ylabel("Pressure (psia)");
subplot(2,2,[3,4]);
plot(L_6_in,Xa_6_in);
title("Conversion vs Length");
xlabel("Length (ft)");
ylabel("Conversion (%)");
sgtitle("6 inches diameter pipe");

%grouped plots
figure;
subplot(2,2,1);
hold on;
plot(L_2_in,T_2_in,"k-");
plot(L_4_in,T_4_in,"k--");
plot(L_6_in,T_6_in,"k:");
title("Temperature vs Length");
xlabel("Length (ft)");
ylabel("Temperature (K)");
legend("2 in","4 in","6 in");
hold off;
subplot(2,2,2);
hold on;
plot(L_2_in,P_2_in,"k-");
plot(L_4_in,P_4_in,"k--");
plot(L_6_in,P_6_in,"k:");
title("Pressure vs Length");
xlabel("Length (ft)");
```

```
ylabel("Pressure (psia)");
legend("2 in","4 in","6 in");
hold off;
subplot(2,2,[3,4]);
hold on;
plot(L_2_in,Xa_2_in,"k-");
plot(L_4_in,Xa_4_in,"k--");
plot(L_6_in,Xa_6_in,"k:");
title("Conversion vs Length");
xlabel("Length (ft)");
ylabel("Conversion (%)");
legend("2 in","4 in","6 in");
hold off;
sgtitle("Grouped plots");

%6 in  - DH exam
Tr = 8.664833333333333e2; %K
dH_ref = 21.96*1000; %cal/mol
%Pipe data:
A = ai_6;
D = di_6;
DO = do_6;
ff = ff_6;
%ODE run
[l,x] =
ode15s(@(L,x)PFR(L,x,T0,P0,F0,M0,v0,Q,Tr,dH_ref,A,ff,D,DO),len_span,y0
);
T_6_in_dh = x(:,7); %K
P_6_in_dh = x(:,8); %Pa
P_6_in_dh = P_6_in_dh./6895;%psia
Fa_6_in_dh = x(:,1);%mol/s
Xa_6_in_dh = (F0-Fa_6_in_dh)./F0;
Xa_6_in_dh = Xa_6_in_dh*100; % (%)
L_6_in_dh = l * 3.281; %ft
%Plots
figure;
subplot(2,2,1);
plot(L_6_in_dh,T_6_in_dh);
title("Temperature vs Length");
xlabel("Length (ft)");
ylabel("Temperature (K)");
subplot(2,2,2);
plot(L_6_in_dh,P_6_in_dh);
title("Pressure vs Length");
xlabel("Length (ft)");
ylabel("Pressure (psia)");
subplot(2,2,[3,4]);
plot(L_6_in_dh,Xa_6_in_dh);
title("Conversion vs Length");
xlabel("Length (ft)");
ylabel("Conversion (%)");
sgtitle("6 inches diameter pipe (with exan given dH)");
```

```
%comparison between the gaussian and the given value
figure;
subplot(3,1,1);
hold on;
plot(L_6_in,Xa_6_in,"k-");
plot(L_6_in_dh,Xa_6_in_dh,"k--");
title("Conversion vs Length (6 in)");
xlabel("Length (ft)");
ylabel("Conversion (%)");
legend("Gaussian","Given");
hold off;
subplot(3,1,2);
hold on;
plot(L_4_in,Xa_4_in,"k-");
plot(L_4_in_dh,Xa_4_in_dh,"k--");
title("Conversion vs Length (4 in)");
xlabel("Length (ft)");
ylabel("Conversion (%)");
legend("Gaussian","Given");
hold off;
subplot(3,1,3);
hold on;
plot(L_2_in,Xa_2_in,"k-");
plot(L_2_in_dh,Xa_2_in_dh,"k--");
title("Conversion vs Length (2 in)");
xlabel("Length (ft)");
ylabel("Conversion (%)");
legend("Gaussian","Given");
hold off;
sgtitle("Comparison of given Heat of reaction vs Gaussian
calculated");



%4 in  - DH exam
Tr = 8.664833333333333e2; %K
dH_ref = 21.96*1000; %cal/mol
%Pipe data:
A = ai_4;
D = di_4;
DO = do_4;
ff = ff_4;
%ODE run
[l,x] =
ode15s(@(L,x)PFR(L,x,T0,P0,F0,M0,v0,Q,Tr,dH_ref,A,ff,D,DO),len_span,y0
);
T_4_in_dh = x(:,7); %K
P_4_in_dh = x(:,8); %Pa
P_4_in_dh = P_4_in_dh./6895;%psia
Fa_4_in_dh = x(:,1);%mol/s
Xa_4_in_dh = (F0-Fa_4_in_dh)./F0;
```

```
Xa_4_in_dh = Xa_4_in_dh*100; % (%)
L_4_in_dh = l * 3.281; % ft
%Plots
figure;
subplot(2,2,1);
plot(L_4_in_dh,T_4_in_dh);
title("Temperature vs Length");
xlabel("Length (ft)");
ylabel("Temperature (K)");
subplot(2,2,2);
plot(L_4_in_dh,P_4_in_dh);
title("Pressure vs Length");
xlabel("Length (ft)");
ylabel("Pressure (psia)");
subplot(2,2,[3,4]);
plot(L_4_in_dh,Xa_4_in_dh);
title("Conversion vs Length");
xlabel("Length (ft)");
ylabel("Conversion (%)");
sgtitle("4 inches diameter pipe (with exam given dH)");

%2 in  - DH exam
Tr = 8.664833333333333e2; %K
dH_ref = 21.96*1000; %cal/mol
%Pipe data:
A = ai_2;
D = di_2;
DO = do_2;
ff = ff_2;
%ODE run
[l,x] =
ode15s(@(L,x)PFR(L,x,T0,P0,F0,M0,v0,Q,Tr,dH_ref,A,ff,D,DO),len_span,y0
);
T_2_in_dh = x(:,7); %K
P_2_in_dh = x(:,8); %Pa
P_2_in_dh = P_2_in_dh./6895;%psia
Fa_2_in_dh = x(:,1);%mol/s
Xa_2_in_dh = (F0-Fa_2_in_dh)./F0;
Xa_2_in_dh = Xa_2_in_dh*100; % (%)
L_2_in_dh = l * 3.281; % ft
%Plots
figure;
subplot(2,2,1);
plot(L_2_in_dh,T_2_in_dh);
title("Temperature vs Length");
xlabel("Length (ft)");
ylabel("Temperature (K)");
subplot(2,2,2);
plot(L_2_in_dh,P_2_in_dh);
title("Pressure vs Length");
xlabel("Length (ft)");
ylabel("Pressure (psia)");
```

```
subplot(2,2,[3,4]);
plot(L_2_in_dh,Xa_2_in_dh);
title("Conversion vs Length");
xlabel("Length (ft)");
ylabel("Conversion (%)");
sgtitle("2 inches diameter pipe (with exam given dH)");

%PFR Function
function f=PFR(L,x,T0,P0,F0,M0,v0,Q,Tr,dH_ref,A,ff,D,DO)
%variables
Fa = x(1);
Fb = x(2);
Fc = x(3);
Fd = x(4);
Fe = x(5);
Ff = x(6);
T = x(7);
P = x(8);
%R gas constant
R = 1.98720425864083;%cal/(mol*K)
%rate constant (s-1)
k = 3.98e12*exp(-59100/(R*T));
%conversion
Xa = (F0-Fa)/F0;
%total molar flow
Ft = Fa+Fb+Fc+Fd+Fe+Ff; %mol/s
%volumetric flow
v = v0*(Ft/F0)*(T/T0)*(P0/P); %m3/s
%concentrations
Ca = (F0-F0*Xa)/v; %mol/m3
Cb = (0.3*F0*Xa) / v; %mol/m3
Cc = (0.065*F0*Xa) / v; %mol/m3
Cd = (0.6675*F0*Xa) / v; %mol/m3
Ce = (0.635*F0*Xa) / v; %mol/m3
Cf = (0.3*F0*Xa) / v; %mol/m3
%reaction rate
ra = -k*Ca; %mol/s*m3
rb = k*Cb; %mol/s*m3
rc = k*Cc; %mol/s*m3
rd = k*Cd; %mol/s*m3
re = k*Ce; %mol/s*m3
rf = k*Cf; %mol/s*m3
%Density
rho = M0/v; %Kg/m3
%heat of reaction
dH = dH_ref + integral(@dCP,Tr,T);
%Heat capacities (cal/molK)
cpA = 21.14 + 0.02056*T;
cpB = 17.88 + 0.01645*T;
cpC = 13.34 + 0.01589*T;
cpD = 12.29 + 0.01022*T;
cpE = 6.98 + 0.01012*T;
```

```
cpF = 6.42 + 0.00082*T;
%Temperature along the length of the reactor
FiCpi = Fa*cpA + Fb*cpB + Fc*cpC + Fd*cpD + Fe*cpE + Fd*cpD + Ff*cpF;
dTdl = (ra*dH - Q*(1/(2*pi*(DO/2))))/(FiCpi) * A;
%Molar flow of A along the length of the reactor
dFadl = ra * A;
%Molar flow of B along the length of the reactor
dFbdl = rb * A;
%Molar flow of C along the length of the reactor
dFcdl = rc * A;
%Molar flow of D along the length of the reactor
dFddl = rd * A;
%Molar flow of E along the length of the reactor
dFedl = re * A;
%Molar flow of F along the length of the reactor
dFfdl = rf * A;
%pressure drop along the length of the reactor
G = M0 / A;
dPdl = -(2*ff*(G^2))/(rho*D);
%final
f = [dFadl;dFbdl;dFcdl;dFddl;dFedl;dFfdl;dTdl;dPdl];
end

function x=dCP(T)
    %heat Capacities (cal/mol*K)
    cpA = 21.14 + 0.02056*T;
    cpB = 17.88 + 0.01645*T;
    cpC = 13.34 + 0.01589*T;
    cpD = 12.29 + 0.01022*T;
    cpE = 6.98 + 0.01012*T;
    cpF = 6.42 + 0.00082*T;
    dCp = -cpA + 0.3*cpB + 0.065*cpC + 0.6675*cpD + 0.653*cpE +
0.3*cpF;
    x = dCp;
end
```

Plots and Results:

Temperature plots

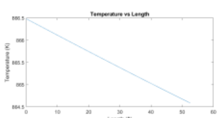


Figure 1 – Temperature vs Length plot of 2 inches diameter pipe (gaussian calculated enthalpy)

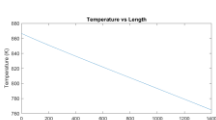


Figure 2 - Temperature vs Length plot of 4 inches diameter pipe (gaussian calculated enthalpy)

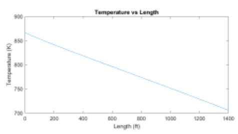


Figure 3 - Temperature vs Length plot of 6 inches diameter pipe (gaussian calculated enthalpy)

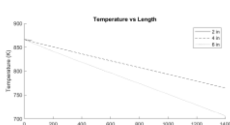


Figure 4 – Grouped Temp vs Len plot (gaussian calculated enthalpy)

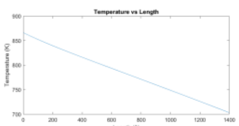


Figure 5 - Temperature vs Length plot of 6 inches diameter pipe (given delta H)

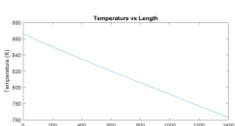


Figure 6 - Temperature vs Length plot of 4 inches diameter pipe (given delta H)

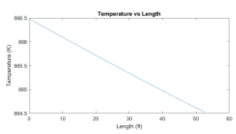


Figure 7 - Temperature vs Length plot of 2 inches diameter pipe (given delta H)

Pressure plots

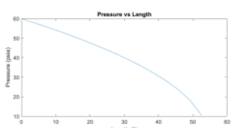


Figure 8 – Pressure vs Length plot for 2 inches diameter pipe (gaussian calculated enthalpy)

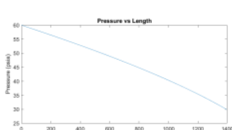


Figure 9 - Pressure vs Length plot for 4 inches diameter pipe (gaussian calculated enthalpy)

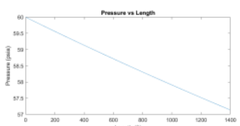


Figure 10 - Pressure vs Length plot for 6 inches diameter pipe (gaussian calculated enthalpy)

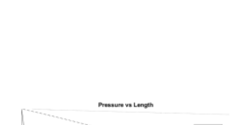


Figure 11 – Grouped Pressure vs Length plot (gaussian calculated enthalpy)

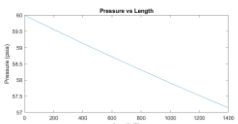


Figure 12 - Pressure vs Length plot for 6 inches diameter pipe (given delta H)

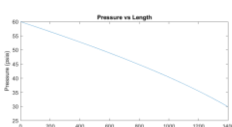


Figure 13 - Pressure vs Length plot for 4 inches diameter pipe (given delta H)

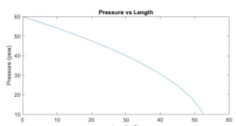


Figure 14 - Pressure vs Length plot for 2 inches diameter pipe (given delta H)

Conversion plots

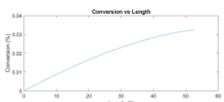


Figure 15 – Conversion vs Length plot for the 2 inches diameter pipe (gaussian calculated enthalpy)

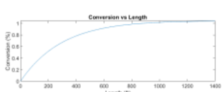


Figure 16 – Conversion vs Length plot for the 4 inches diameter pipe (gaussian calculated enthalpy)

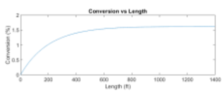


Figure 17 - Conversion vs Length plot for the 6 inches diameter pipe (gaussian calculated enthalpy)

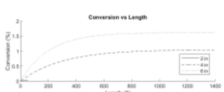


Figure 18 – Grouped Conversion vs Length plot (gaussian calculated enthalpy)

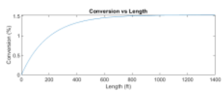


Figure 19 – Conversion vs Length plot for the 6 inches diameter pipe (given delta H)

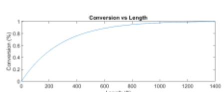


Figure 20 - Conversion vs Length plot for the 4 inches diameter pipe (given delta H)

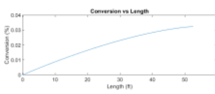


Figure 21 - Conversion vs Length plot for the 4 inches diameter pipe (given delta H)

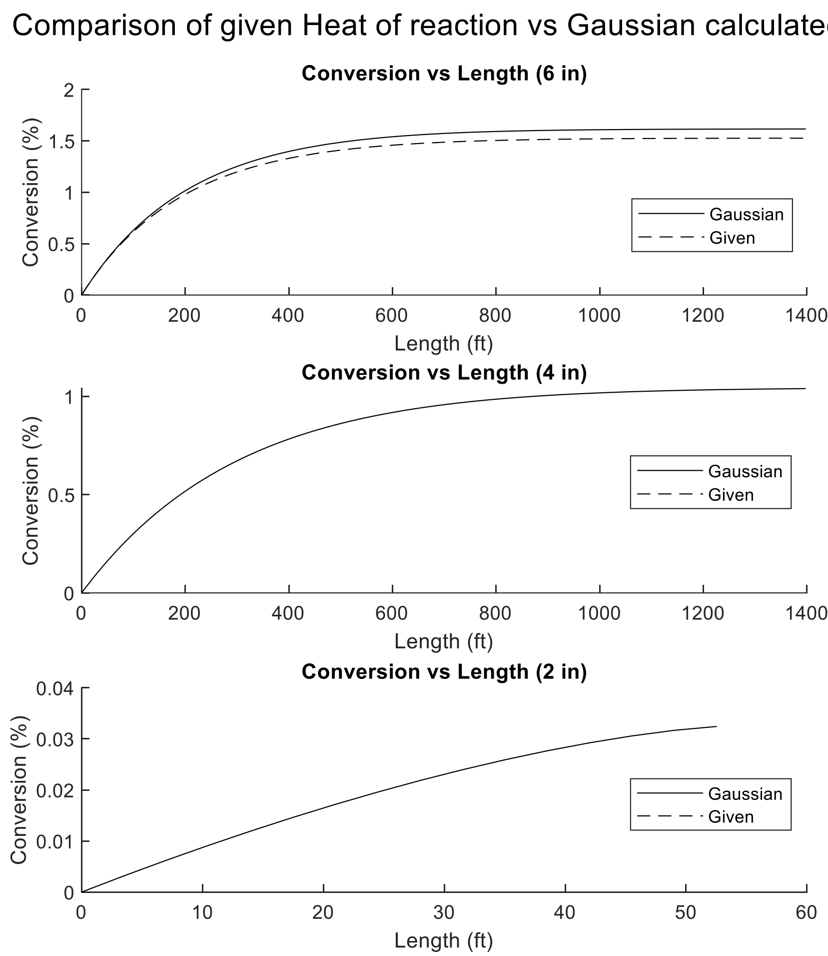


Figure 22 – Comparison of given Heat of Reaction vs Gaussian calculated per each diameter

Optimal pipe

Since there is some error in my conversion model, I can't calculate the optimal pipe to be used, but method to find which one is the better option is as follows:

1. Find the length required for the pipe to reach a conversion of 80%.
2. Discard the pipe in which the pressure at that length is lower than 25 psia.
3. Multiply the pipe length by its corresponding weight per ft (found in the engineering toolbox).
4. Select the lightest pipe.