Homework 6

Problem 2.1 and 2.2

Repeat problem 1 for $z_A = 0.30$

In [ ]:

```
import matplotlib.pyplot as plt
import numpy as np
from scipy.interpolate import interp1d

molFrac = np.linspace(0,1,9999)                                    #array of

T = np.array([64.5,66,69.3,73.1,78,84.4,89.3,93.5,100])            #temp dat
yA = np.array([1,.958,.87,.779,.665,.517,.365,.23,0])              #sat vap
xA = np.array([1,.9,.7,.5,.3,.15,.08,.04,0])                       #sat liq

interpX = interp1d(xA,T,kind='cubic')
interpY = interp1d(yA,T,kind='cubic')
interpTx = interp1d(T,xA,kind='cubic')
interpTy = interp1d(T,yA,kind='cubic')
```

In [ ]:

```
mix = 0.3                                                      #mix comp
Tdew = interpY(mix)                                            #dew point te

TdewApprox = []                                                #this loop fi
for i in interpX(molFrac):
    if i <=Tdew and i >Tdew-0.1:
        TdewApprox.append(i)

xDew = molFrac[interpX(molFrac).tolist().index(max(TdewApprox))]       #comp of firs
# print('T_dew =',Tdew)
# print('x_dew =',xDew)

Tbub = 78.0
ybub = 0.665
```

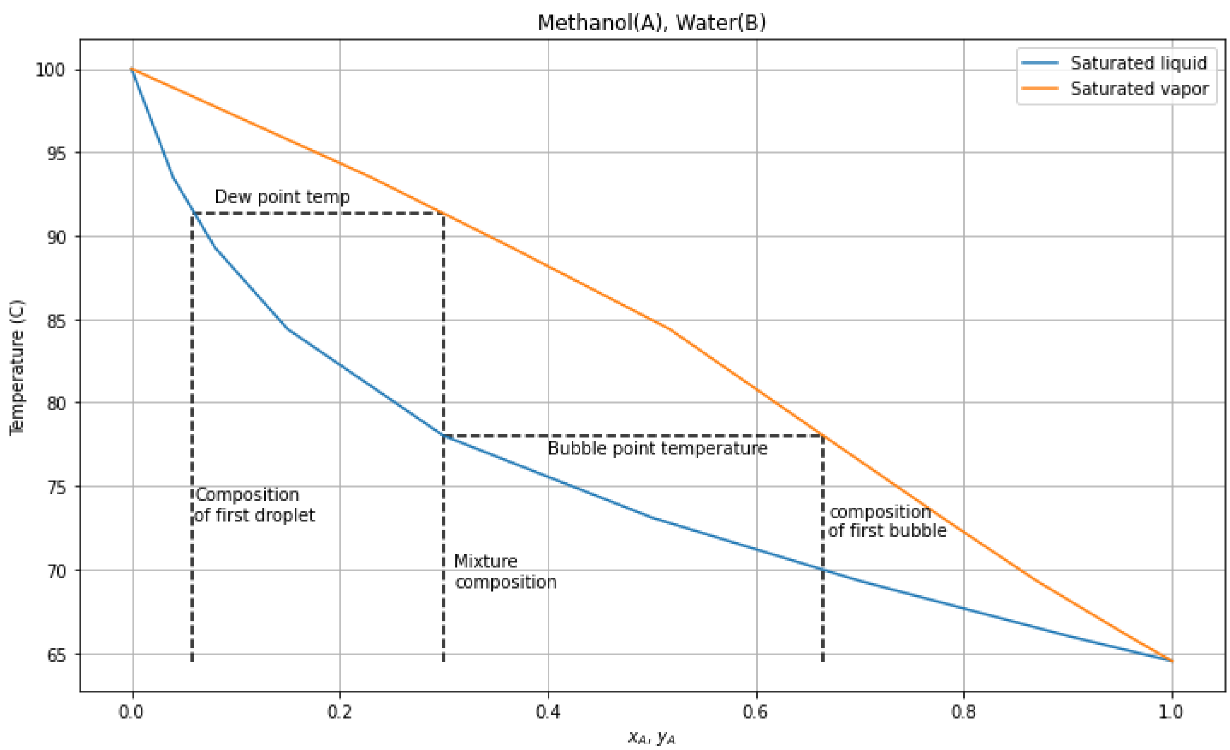
Following the same logic as problem 1, the dew point temperature is found when $y_A = 0.30$ and the bubble point temperature is found when $x_A = 0.30$. The composition of the first vapor bubble is y_A at the bubble point temperature and the composition of the first droplet is x_A at the dew point temperature. </br></br> The dew point temperature is about $91.3\degree C$ and the composition of the first droplet is about 5.90% methanol. The bubble point temperature is $78.0\degree C$ and the composition of the first bubble is 66.5%. Below is a graphical representation of the process.

In [ ]:

```
plt.figure(figsize=(12,7))
plt.plot(xA,T,label='Saturated liquid')
plt.plot(yA,T,label='Saturated vapor')

plt.vlines(mix,min(T),Tdew,linestyles='--',color='k')
plt.vlines(xDew,min(T),Tdew,linestyles='--',color='k')
```

```
plt.hlines(Tdew,xDew,mix,linestyles='--',color='k')
plt.hlines(Tbub,mix,ybub,linestyles='--',color='k')
plt.vlines(ybub,min(T),Tbub,linestyles='--',color='k')

plt.text(.06,73,'Composition\nof first droplet')
plt.text(.08,92,'Dew point temp')
plt.text(.31,69,'Mixture\ncomposition')
plt.text(.4,77,'Bubble point temperature')
plt.text(.67,72,'composition\nof first bubble')

plt.xlabel(r'$x_A$, $y_A$')
plt.ylabel('Temperature (C)')
plt.grid()
plt.title('Methanol(A), Water(B)')
plt.legend()
;
```

Out[ ]: ''



Problem 2.3

For this problem, the inverse lever arm rule becomes

$$0.20 = \frac{0.30 - a}{c - a}$$

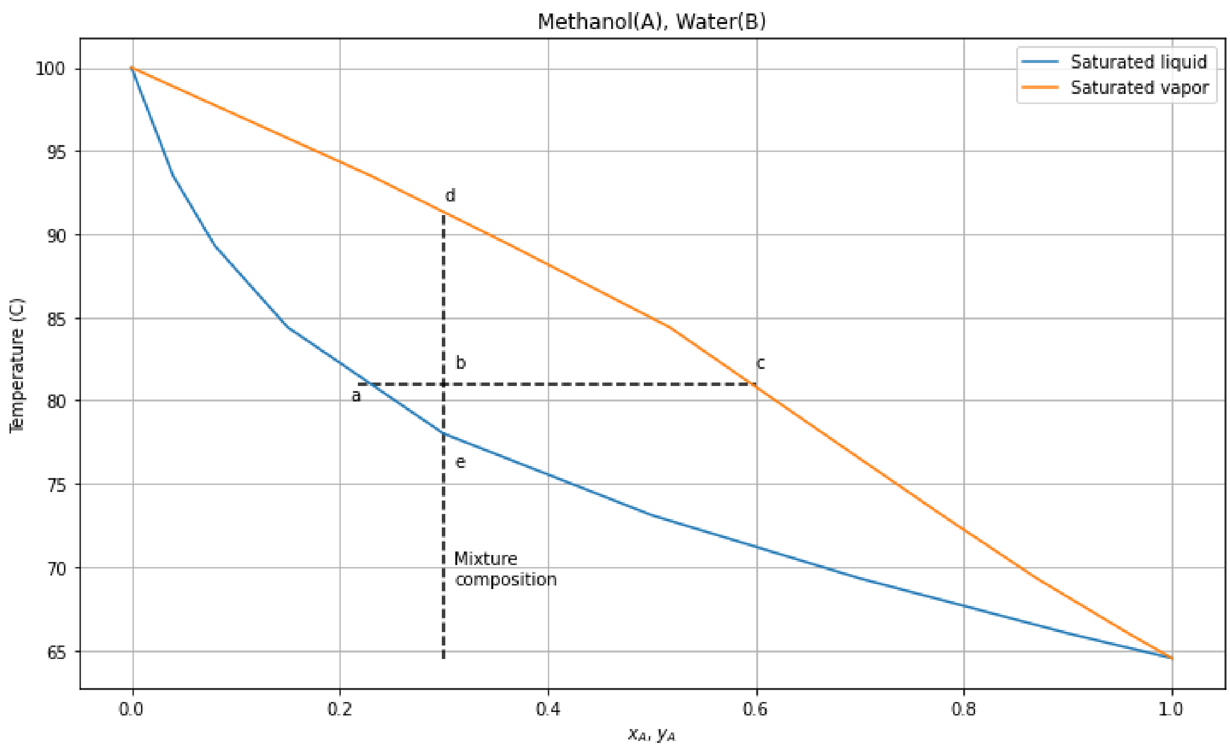
where a and c are depicted in the plot below.

In [ ]:

```
plt.figure(figsize=(12,7))
plt.plot(xA,T,label='Saturated liquid')
plt.plot(yA,T,label='Saturated vapor')

plt.vlines(mix,min(T),Tdew,linestyles='--',color='k')
plt.hlines(81,interpTx(81),interpTy(81),linestyles='--',color='k')
```

```
plt.text(.31,69,'Mixture\ncomposition')
plt.text(.21,80,'a')
plt.text(.31,82,'b')
plt.text(.6,82,'c')
plt.text(.3,92,'d')
plt.text(.31,76,'e')
plt.xlabel(r'$x_A$, $y_A$')
plt.ylabel('Temperature (C)')
plt.grid()
plt.title('Methanol(A), Water(B)')
plt.legend()

;
```

Out[ ]: ''



In [ ]:

```
possibY = []                                            #loop to make array of po
for i in range(len(molFrac)):
    if molFrac[i] < ybub and molFrac[i] > mix:
        possibY.append(molFrac[i])
possibY = np.array(possibY)
possibX = interpTx(interpY(possibY))                    #possible x values
```

In [ ]:

```
sol = (mix-possibX)/(possibY-possibX)                   #solution to eq1
sol = sol.tolist()

for i in sol:                                           #loop to find x,y to achi
    if .2/i >=.999 and .2/i <=1:
        percVap = i
        print(possibX[sol.index(i)],possibY[sol.index(i)],i)
print(interpY(possibY[sol.index(percVap)]))
```

```
0.22385853657263613 0.6045209041808361 0.20002361648139882
80.71510197550057
```

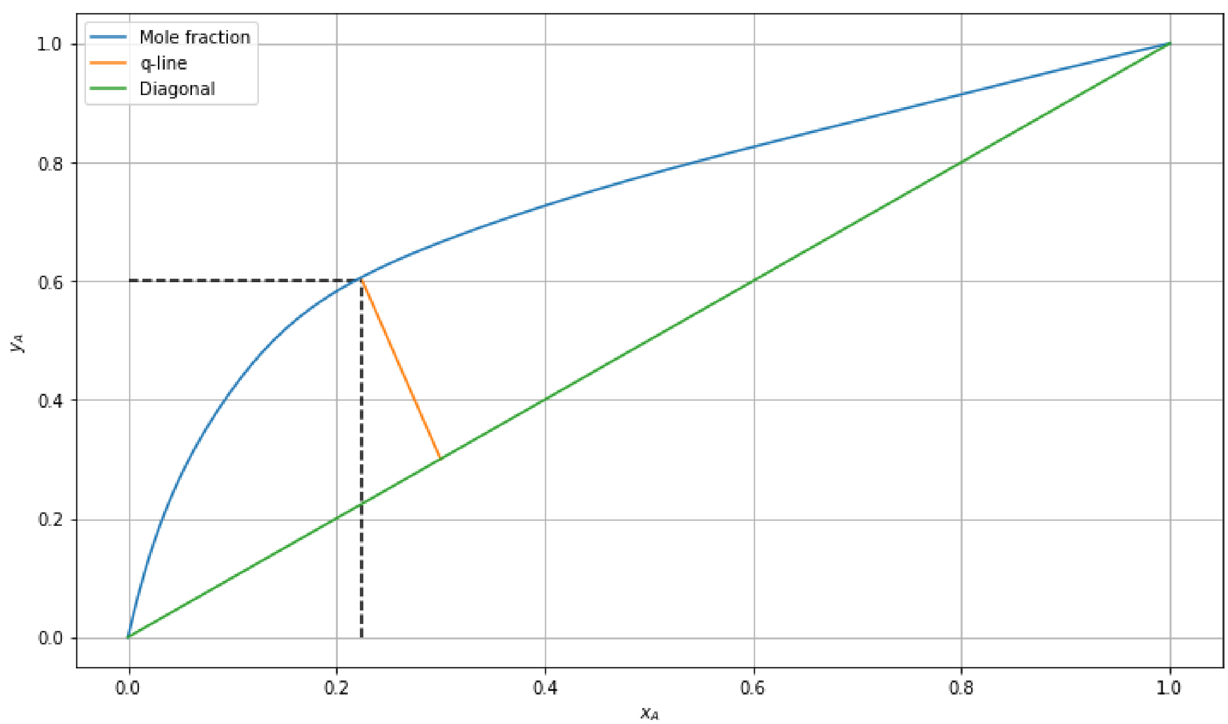
Using the inverse lever arm rule, the temperature at which 20% of the mixture is vaporized when 30% is methanol, is about $80.7\degree C$. The composition of the liquid phase is about 22.4% methanol and the composition of the vapor phase is about 60.5% methanol.

Problem 2.4

Use q-line

In [ ]:
```
def qline(V,F,z,x):
    return (V/F-1)*F/V*x+F/V*z
plt.figure(figsize=(12,7))
plt.plot(interpTx(interpX(molFrac)),interpTy(interpX(molFrac)),label='Mole fraction')
plt.plot([.225,.3],qline(.2,1,.3,np.array([.225,.3])),label='q-line')
plt.plot([0,1],[0,1],label='Diagonal')
plt.hlines(qline(.2,1,.3,.225),0,.225,linestyles='--',color='k')
plt.vlines(.225,0,qline(.2,1,.3,.225),linestyles='--',color='k')
plt.xlabel(r'$x_A$')
plt.ylabel(r'$y_A$')
plt.grid()
plt.legend()

;
print(interpX(.46))
```

```
73.92669644249968
```



According to the above plot, $x_A \approx 0.24$ and $y_A \approx 0.60$ which would indicate that the temperature is about $74.0\degree C$. These results are similar to those found with the inverse lever arm rule.