In [20]:
```
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")

import pickle
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sklearn.cross_validation import train_test_split
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import accuracy_score
from sklearn.cross_validation import cross_val_score
from collections import Counter
from sklearn.metrics import accuracy_score
from sklearn import cross_validation
from sklearn.naive_bayes import MultinomialNB
from sklearn.metrics import f1_score
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import precision_recall_fscore_support
from sklearn.metrics import classification_report
from prettytable import PrettyTable
import random
from sklearn.metrics import roc_curve, auc
from sklearn.learning_curve import validation_curve
from sklearn.metrics import fbeta_score, make_scorer
from sklearn.metrics import precision_score, recall_score,roc_auc_score
from sklearn.preprocessing import StandardScaler
from sklearn.decomposition import TruncatedSVD
from sklearn.metrics import roc_auc_score
import scikitplot as skplt

import sqlite3
import pandas as pd
import numpy as np
import nltk
import string
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.feature_extraction.text import TfidfTransformer
from sklearn.feature_extraction.text import TfidfVectorizer

from sklearn.feature_extraction.text import CountVectorizer
from sklearn.metrics import confusion_matrix
from sklearn import metrics
from sklearn.metrics import roc_curve, auc
from nltk.stem.porter import PorterStemmer

#import nltk
#nltk.download('stopwords')

import re
# Tutorial about Python regular expressions: https://pymotw.com/2/re/
import string
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer
from nltk.stem.wordnet import WordNetLemmatizer
```

```
#from gensim.models import KeyedVectors
#model = KeyedVectors.load_word2vec_format('GoogleNews-vectors-negative300.bin.gz

#import gensim
from gensim.models import Word2Vec
from gensim.models import KeyedVectors
import pickle

# ================================================================================
```

In [19]:
```
# using the SQLite Table to read data.
con = sqlite3.connect('database.sqlite')


#filtering only positive and negative reviews i.e.
# not taking into consideration those reviews with Score=3
#filtered_data2 = pd.read_sql_query(""" SELECT * FROM Reviews WHERE Id <= 10000"
#taking into consideration only 10K entries because of memory contrain
filtered_data  = pd.read_sql_query(""" SELECT * FROM Reviews WHERE Score != 3  "
print(filtered_data.shape)

# Give reviews with Score>3 a positive rating, and reviews with a score<3 a negat
def partition(x):
    if x < 3:
        return 0
    return 1

#changing reviews with score less than 3 to be positive and vice-versa
actualScore = filtered_data['Score']
positiveNegative = actualScore.map(partition)
filtered_data['Score'] = positiveNegative
print(filtered_data.shape)
```

```
(525814, 10)
(525814, 10)
```

In [94]:
```
#Sorting 60K data according to TimeStamp in ascending order
sorted_data=filtered_data.sort_values('Time', axis=0, ascending=True, inplace=Fal
sorted_data.count()
print(type(sorted_data))

#Deduplication of entries
final2=sorted_data.drop_duplicates(subset={"UserId","ProfileName","Time","Text"},
final = final2.head(60000) #selecting first 60K rows of data based on TimeStamp
final.shape
#final2.shape
#print(type(final))
#print(type(final2))
#final.head
#Observation: Removing deuplicate entries with ID<=10K
```

```
<class 'pandas.core.frame.DataFrame'>
```

Out[94]:
```
(60000, 10)
```

In [95]:
```
import pickle
sorted_data2 = sorted_data.to_pickle("./sorted_data_to_file.pkl") #saving a Data
```

In [96]:
```
display= pd.read_sql_query("""
SELECT *
FROM Reviews
WHERE HelpfulnessNumerator > HelpfulnessDenominator
ORDER BY ProductID
""", con)

display.head()
final.shape
##Observation: No such entry is found where denominator is less than numerator
```

Out[96]: (60000, 10)

In [97]:
```
# find sentences containing HTML tags
import re
i=0;
for sent in final['Text'].values:
    if (len(re.findall('<.*?>', sent))):
        print(i)
        print(sent)
        break;
    i += 1;
```

```
8
What happens when you say his name three times? Michael Keaten stars in this co
medy about two couples that live in an old two story house.  While coming back
from a supply store, the couple suddenly get caught inside of a  &quot;broken-u
p&quot; bridge and then just before they start to tumble down  into the lake, a
board catches them.  But just when they've got their hopes  up, and small dog s
teps on the board and the car starts to slide off the  bridge and into the lake
waters.  A few minutes later...<p>They find  themselves back into their home, t
hey find that somehow somehad light the  fireplace, as if done by magic.  From
then on, they find a weird-looking  dead guy known as Bettlejuice.  The only wa
y they can get him for help is  to call him by his name three times and he will
appear at their survice.  But they soon wish that they have never called his na
me, because  Bettlejuice was once a troublemaker but he is the only one who can
save  them, on the account that they said his name three times.  They can't lea
ve  their houses or else they will find theirselves in another world with giant
sandworms.  This is a stellar comedy that you should see! Michael Keaton is  aw
esome as he plays the leading role of Bettlejuice.
```

In [98]:
```
stop = set(stopwords.words('english')) #set of stopwords
sno = nltk.stem.SnowballStemmer('english') #initialising the snowball stemmer

def cleanhtml(sentence): #function to clean the word of any html-tags
    cleanr = re.compile('<.*?>')
    cleantext = re.sub(cleanr, ' ', sentence)
    return cleantext
def cleanpunc(sentence): #function to clean the word of any punctuation or specia
    cleaned = re.sub(r'[?|!|\'|"|#]',r'',sentence)
    cleaned = re.sub(r'[.|,|)|(|\|/]',r' ',cleaned)
    return  cleaned
print(stop)
print('************************************')
print(sno.stem('tasty'))
```

```
{'o', "haven't", 'now', 'what', 'when', "should've", 'before', 'shan', "are
n't", 'below', 'under', 'off', 'which', 'through', 'other', 'been', 'between',
"mightn't", 'shouldn', 'mightn', 'who', 'am', "you'll", 'over', 'until', 'ther
e', 'all', 'they', "needn't", 'do', "you're", 'in', 'we', 'm', 'them', 'yoursel
ves', 'for', 'into', "she's", 'has', "shouldn't", 'himself', 'it', 'some', 'a
s', 'further', 'an', "won't", 'of', "mustn't", 'myself', 'did', 'doesn', 'to',
'not', 'nor', 'this', "that'll", 'during', 'doing', "don't", 'can', 'i', 'dow
n', 'yours', 'she', 'very', 'didn', "it's", 'these', 'more', 'have', 'is', 'hi
s', 'only', 'me', 'won', 'up', 'mustn', 'each', 'few', 'whom', 'those', "could
n't", 'while', 'or', "shan't", "hadn't", 'how', 'such', 'him', 'any', 'ma', 'ai
n', "didn't", 'because', "wouldn't", 'theirs', 'but', 'you', 'are', 'my', 'a',
'and', 'once', 'don', 'no', 'had', 'on', 'after', 'hasn', 'should', 'its', 's',
"isn't", 'too', 'that', "hasn't", 'd', 'wasn', 'y', 'ours', 'needn', "weren't",
'were', 'your', 'by', 'haven', 'same', 't', 'hadn', 'was', 'about', "you'd", 't
hen', 'here', 'from', 'own', 'both', 'their', 'just', "doesn't", 'themselves',
'again', 'herself', 'at', 'with', 'couldn', 'if', 'so', 'wouldn', 'the', 've',
'than', 'yourself', 'having', "you've", 'will', 'isn', 'be', 'where', 'does',
'out', 'hers', 'why', 'weren', 'most', 'our', 'he', "wasn't", 'ourselves', 'its
elf', 'against', 'aren', 're', 'being', 'above', 'll', 'her'}
************************************
tasti
```

In [99]:
```
#Code for implementing step-by-step the checks mentioned in the pre-processing ph
# this code takes a while to run as it needs to run on 60K sentences.
i=0
str1=' '
final_string=[]
all_positive_words=[] # store words from +ve reviews here
all_negative_words=[] # store words from -ve reviews here.
s=''
for sent in final['Text'].values:
    filtered_sentence=[]
    #print(sent);
    sent=cleanhtml(sent) # remove HTML tags
    for w in sent.split():
        for cleaned_words in cleanpunc(w).split():
            if((cleaned_words.isalpha()) & (len(cleaned_words)>2)):
                if(cleaned_words.lower() not in stop):
                    s=(sno.stem(cleaned_words.lower())).encode('utf8')
                    filtered_sentence.append(s)
                    if (final['Score'].values)[i] == 'positive':
                        all_positive_words.append(s) #list of all words used to c
                    if(final['Score'].values)[i] == 'negative':
                        all_negative_words.append(s) #list of all words used to c
                else:
                    continue
            else:
                continue
    #print(filtered_sentence)
    str1 = b" ".join(filtered_sentence) #final string of cleaned words
    #print("*****************************************************************

    final_string.append(str1)
    i+=1
```

In [100]:
```
final['CleanedText']=final_string #adding a column of CleanedText which displays
final['CleanedText']=final['CleanedText'].str.decode("utf-8")
print(final.shape)
```

```
(60000, 11)
```

In [101]:
```
final.head(3) #below the processed review can be seen in the CleanedText Column

# store final table into an SQLite table for future.
conn = sqlite3.connect('final.sqlite')
c=conn.cursor()
conn.text_factory = str
final.to_sql('Reviews', conn,  schema=None, if_exists='replace', index=True, inde

import pickle
final2 = final.to_pickle("./final_to_file2.pkl") #saving a DataFrame on disk

final.shape
#print(final2.shape)
```

Out[101]:
```
(60000, 11)
```

In [102]:
```
# create design matrix X and target vector y
X = np.array(final.iloc[:,:]) # end index is exclusive
y = np.array(final['Score']) # showing you two ways of indexing a pandas df
```

In [103]:
```
X_train = X[0:38400:1]
X_cv = X[38400:48000:1]
X_test = X[48000:60000:1]

y_train = y[0:38400:1]
y_cv = y[38400:48000:1]
y_test =y[48000:60000:1]

print(X_train.shape)
print(X_cv.shape)
print(X_test.shape)
print(y_train.shape)
print(y_cv.shape)
print(y_test.shape)
```

```
(38400, 11)
(9600, 11)
(12000, 11)
(38400,)
(9600,)
(12000,)
```

In [104]:
```
#Writing splitted data with cross-validation data
# open the file for writing an array to fileto be save on disk from X_train data
fileObject = open("./train_to_file.pkl",'wb')
pickle.dump(X_train,fileObject)   # this writes the object a to the file
fileObject.close() # here we close the fileObject

# open the file for writing an array to fileto be save on disk from X_test data
fileObject = open("./x_cv_to_file.pkl",'wb')
pickle.dump(X_cv,fileObject)   # this writes the object a to the file
fileObject.close() # here we close the fileObject

# open the file for writing an array to fileto be save on disk from X_test data
fileObject = open("./x_test_to_file.pkl",'wb')
pickle.dump(X_test,fileObject)   # this writes the object a to the file
fileObject.close() # here we close the fileObject

# open the file for writing an array to fileto be save on disk from y_train data
fileObject = open("./y_train_to_file.pkl",'wb')
pickle.dump(y_train,fileObject)   # this writes the object a to the file
fileObject.close() # here we close the fileObject

# open the file for writing an array to fileto be save on disk from y_test data
fileObject = open("./y_cv_to_file.pkl",'wb')
pickle.dump(y_cv,fileObject)   # this writes the object a to the file
fileObject.close() # here we close the fileObject

# open the file for writing an array to fileto be save on disk from y_test data
fileObject = open("./y_test_to_file.pkl",'wb')
pickle.dump(y_test,fileObject)   # this writes the object a to the file
fileObject.close() # here we close the fileObject
```

In [3]:
```
fileObject = open("./train_to_file.pkl",'rb') # we open the file for reading
X_train = pickle.load(fileObject) # load the object from the file

fileObject = open("./x_cv_to_file.pkl",'rb') # we open the file for reading
X_cv = pickle.load(fileObject) # load the object from the file

fileObject = open("./x_test_to_file.pkl",'rb') # we open the file for reading
X_test = pickle.load(fileObject) # load the object from the file

fileObject = open("./y_train_to_file.pkl",'rb') # we open the file for reading
y_train = pickle.load(fileObject) # load the object from the file

fileObject = open("./y_cv_to_file.pkl",'rb') # we open the file for reading
y_cv = pickle.load(fileObject) # load the object from the file

fileObject = open("./y_test_to_file.pkl",'rb') # we open the file for reading
y_test = pickle.load(fileObject) # load the object from the file
```

In [4]:
```
#Appling BoW to fit and transform
count_vect =  CountVectorizer()
bow_NB = count_vect.fit(X_train[:,9])
train_bow_nstd = count_vect.transform(X_train[:,9])
cv_bow_nstd = count_vect.transform(X_cv[:,9])
test_bow_nstd = count_vect.transform(X_test[:,9])

print("the type of count vectorizer ",type(train_bow_nstd))
print("the number of unique words ", test_bow_nstd.get_shape()[1])

print(train_bow_nstd.shape)
print(cv_bow_nstd.shape)
print(test_bow_nstd.shape)
print(y_train.shape)
print(y_cv.shape)
print(y_test.shape)
```

```
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the number of unique words  37996
(38400, 37996)
(9600, 37996)
(12000, 37996)
(38400,)
(9600,)
(12000,)
```

In [5]:
```
# Column Standardization of the BoW non-standard vector
std_scal = StandardScaler(with_mean=False)
std_scal.fit(train_bow_nstd)
train_bow = std_scal.transform(train_bow_nstd)
cv_bow = std_scal.transform(cv_bow_nstd)
test_bow = std_scal.transform(test_bow_nstd)
```

```
C:\Users\AbhiShek\Anaconda3\lib\site-packages\sklearn\utils\validation.py:475:
DataConversionWarning: Data with input dtype int64 was converted to float64 by
StandardScaler.
  warnings.warn(msg, DataConversionWarning)
C:\Users\AbhiShek\Anaconda3\lib\site-packages\sklearn\utils\validation.py:475:
DataConversionWarning: Data with input dtype int64 was converted to float64 by
StandardScaler.
  warnings.warn(msg, DataConversionWarning)
C:\Users\AbhiShek\Anaconda3\lib\site-packages\sklearn\utils\validation.py:475:
DataConversionWarning: Data with input dtype int64 was converted to float64 by
StandardScaler.
  warnings.warn(msg, DataConversionWarning)
C:\Users\AbhiShek\Anaconda3\lib\site-packages\sklearn\utils\validation.py:475:
DataConversionWarning: Data with input dtype int64 was converted to float64 by
StandardScaler.
  warnings.warn(msg, DataConversionWarning)
```

In [36]:
```
roc_score_train = []
roc_score_cv = []
length = (train_bow.shape)
length[0]
pred = []
length1 = (cv_bow.shape)
length1[0]
cv_scores = []
train_scores = []

for i in range(1,30,2):
    # instantiate learning model (k = 30)
    knn = KNeighborsClassifier(n_neighbors=i,algorithm='brute')

    # fitting the model on crossvalidation train
    knn.fit(train_bow, y_train)

    #ROC score of Train Data
    train_prob = []
    for m in range(0,length[0],1000):
        train_prob.extend(knn.predict_proba(train_bow[m:m+1000]))

    train_prob2 = np.asarray(train_prob)
    train_prob3 = train_prob2[:,1]
    scores_train = roc_auc_score(y_train,train_prob3)
    roc_score_train.append(scores_train)

    cv_prob = []
    for n in range(0,length1[0],1000):
        cv_prob.extend(knn.predict_proba(cv_bow[n:n+1000]))

    cv_prob2 = np.asarray(cv_prob)
    cv_prob3 = cv_prob2[:,1]
    scores_cv = roc_auc_score(y_cv,cv_prob3)
    roc_score_cv.append(scores_cv)

    print("For Hyperparameter value of K = ",i)
    print("AUC Score on Train Data: ",roc_score_train[-1])
    print("AUC Score on CV Data: ",roc_score_cv[-1])
    print("**************")

# open the file for writing an array to fileto be save on disk
fileObject = open("./train_scores_to_file.pkl",'wb')
pickle.dump(roc_score_train,fileObject)   # this writes the object a to the file
fileObject.close() # here we close the fileObject

# open the file for writing an array to fileto be save on disk
fileObject = open("./cv_scores_to_file.pkl",'wb')
pickle.dump(roc_score_cv,fileObject)   # this writes the object a to the file
fileObject.close() # here we close the fileObject
```

```
For Hyperparameter value of K =  1
AUC Score on Train Data:  1.0
AUC Score on CV Data:  0.5582674924785005
**************
For Hyperparameter value of K =  3
AUC Score on Train Data:  0.9594771027488411
```

```
AUC Score on CV Data:  0.6250104003035225
**************
For Hyperparameter value of K =  5
AUC Score on Train Data:  0.9385711616123557
AUC Score on CV Data:  0.6596131461500572
**************
For Hyperparameter value of K =  7
AUC Score on Train Data:  0.9259650548015257
AUC Score on CV Data:  0.678437331515083
**************
For Hyperparameter value of K =  9
AUC Score on Train Data:  0.9158882624788621
AUC Score on CV Data:  0.6928264634475093
**************
For Hyperparameter value of K =  11
AUC Score on Train Data:  0.9072456993055835
AUC Score on CV Data:  0.7009720331678159
**************
For Hyperparameter value of K =  13
AUC Score on Train Data:  0.9021957926517195
AUC Score on CV Data:  0.7043640921616656
**************
For Hyperparameter value of K =  15
AUC Score on Train Data:  0.8993252358790145
AUC Score on CV Data:  0.7096724070795283
**************
For Hyperparameter value of K =  17
AUC Score on Train Data:  0.896033598012779
AUC Score on CV Data:  0.7072664008626427
**************
For Hyperparameter value of K =  19
AUC Score on Train Data:  0.8920539510941903
AUC Score on CV Data:  0.7103917960741767
**************
For Hyperparameter value of K =  21
AUC Score on Train Data:  0.887462552352344
AUC Score on CV Data:  0.7075662416131953
**************
For Hyperparameter value of K =  23
AUC Score on Train Data:  0.8828179726804415
AUC Score on CV Data:  0.7148916433977209
**************
For Hyperparameter value of K =  25
AUC Score on Train Data:  0.8789373654344946
AUC Score on CV Data:  0.7163441497876674
**************
For Hyperparameter value of K =  27
AUC Score on Train Data:  0.8764789738339384
AUC Score on CV Data:  0.7164040555359568
**************
For Hyperparameter value of K =  29
AUC Score on Train Data:  0.8739527845853725
AUC Score on CV Data:  0.7175369605986581
**************
```

In [6]:
```
fileObject = open("./train_scores_to_file.pkl",'rb') # we open the file for read
train_scores = pickle.load(fileObject) # load the object from the file

fileObject = open("./cv_scores_to_file.pkl",'rb') # we open the file for reading
cv_scores = pickle.load(fileObject) # load the object from the file
```

In [7]:
```
# creating odd list of K for KNN
myList = list(range(0,30))
neighbors = list(filter(lambda x: x % 2 != 0, myList))
neighbors
```

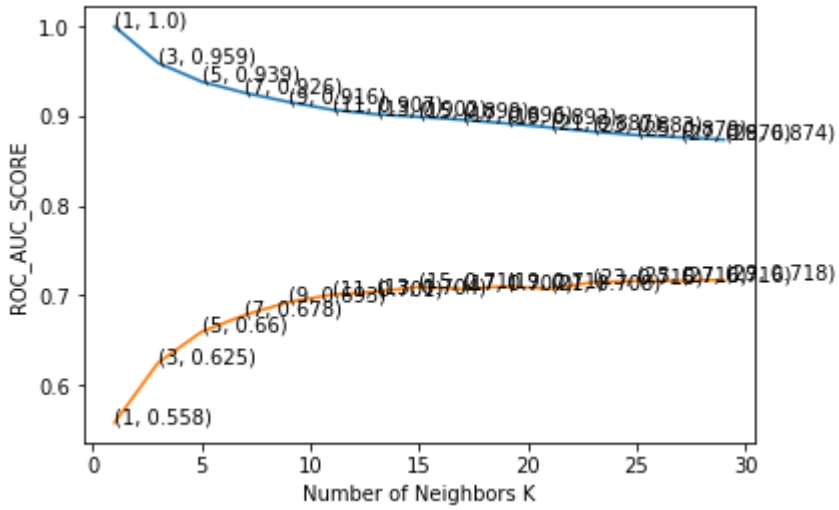
Out[7]:
```
[1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29]
```

In [8]:
```
plt.plot(neighbors, train_scores)
plt.plot(neighbors, cv_scores)

for xy in zip(neighbors, np.round(train_scores,3)):
    plt.annotate('(%s, %s)' % xy, xy=xy, textcoords='data')
for xy in zip(neighbors, np.round(cv_scores,3)):
    plt.annotate('(%s, %s)' % xy, xy=xy, textcoords='data')

plt.xlabel('Number of Neighbors K')
plt.ylabel('ROC_AUC_SCORE')

plt.show()
```



In [9]:
```
#Training KNN for best hyperparameter
knn = KNeighborsClassifier(29,algorithm='brute')
knn.fit(train_bow,y_train)
#pred = knn.predict(test_bow)
```

Out[9]:
```
KNeighborsClassifier(algorithm='brute', leaf_size=30, metric='minkowski',
           metric_params=None, n_jobs=1, n_neighbors=29, p=2,
           weights='uniform')
```

In [10]:
```
length = (test_bow.shape)
length[0]
```

Out[10]:
```
12000
```

In [11]:
```
#finding roc_auc_score on test data
roc_score_test = []
length3 = (test_bow.shape)
pred_test = []
for i in range(0,length3[0],1000):
    pred_test.extend(knn.predict_proba(test_bow[i:i+1000]))

test_prob2 = np.asarray(pred_test)
test_prob3 = test_prob2[:,1]
scores_test = roc_auc_score(y_test,test_prob3)
roc_score_test.append(scores_test)

#second method
fpr, tpr, thresholds = roc_curve(y_test, test_prob3)
roc_auc = auc(fpr, tpr,reorder='deprecated')
#this will work
```

In [12]:
```
print(roc_score_test)
print(roc_auc)
```

```
[0.7076795890026133]
0.7076795890026133
```

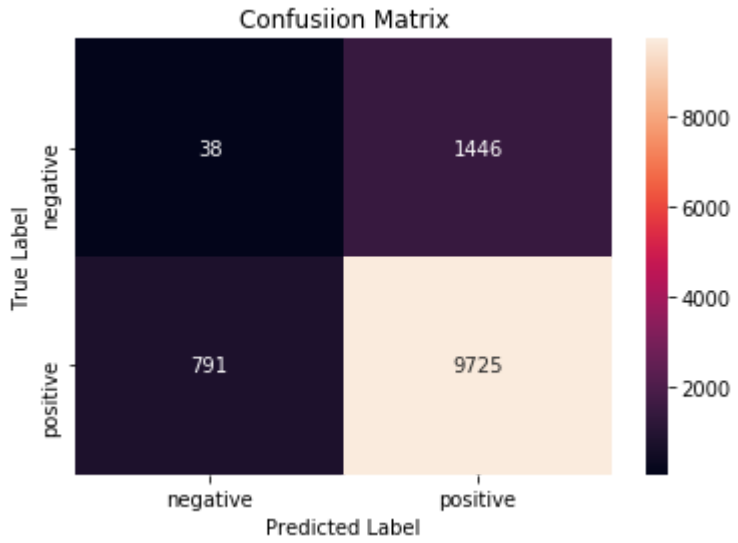
In [14]:
```
#defining own threshhold for prediction over probability values
def pred(y):
    y_pred = []
    for i in y:
        if i.all()>=0.5:
            y_pred.append(1)
        else:
            y_pred.append(0)
    return y_pred

y_pred = pred(pred_test)
```

In [15]:
```
# Confusion Matrix on Test Data
#y_pred = np.argmax(pred_test, axis=1)
cm_bow = confusion_matrix(y_test, y_pred)
cm_bow
```

Out[15]:
```
array([[  38, 1446],
       [ 791, 9725]], dtype=int64)
```

In [16]:
```
# plot confusion matrix to describe the performance of classifier.
import seaborn as sns
class_label = ["negative", "positive"]
df_cm = pd.DataFrame(cm_bow, index = class_label, columns = class_label)
sns.heatmap(df_cm, annot = True, fmt = "d")
plt.title("Confusiion Matrix")
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.show()
```



In [17]:
```
# To show main classification report
from sklearn.metrics import classification_report
print(classification_report(y_test, y_pred))
```

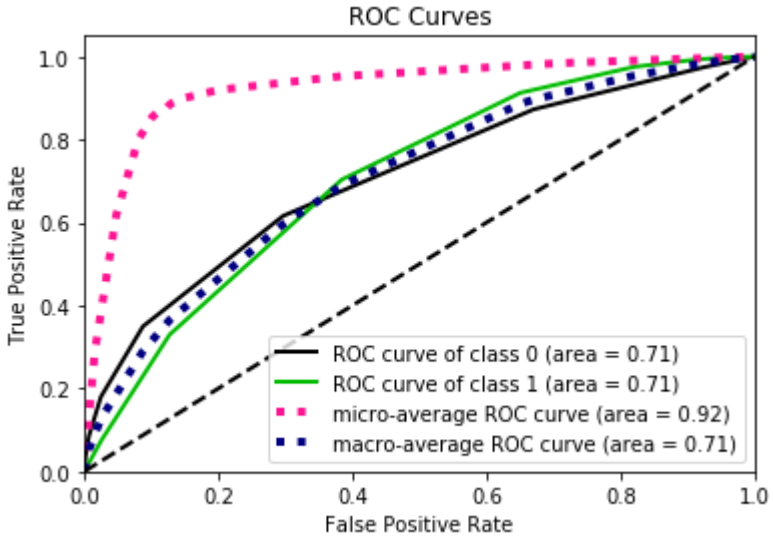
```
             precision    recall  f1-score   support

          0       0.05      0.03      0.03      1484
          1       0.87      0.92      0.90     10516

avg / total       0.77      0.81      0.79     12000
```

In [21]:
```
#Plotting ROC curve over Test Data
skplt.metrics.plot_roc_curve(y_test, pred_test)
```

Out[21]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1609cbbe630>
```



BoW - KD Tree

In [22]:
```
svd = TruncatedSVD()
train_bow_dn = svd.fit_transform(train_bow)
cv_bow_dn = svd.transform(cv_bow)
test_bow_dn = svd.transform(test_bow)
#X_tr_input = X_tr_input1
#x_cv_input = x_cv_input1
```

In [7]:
```
roc_score_train_dn = []
roc_score_cv_dn = []
length = (train_bow_dn.shape)
length[0]
length1 = (cv_bow_dn.shape)
length1[0]
cv_scores_dn = []
train_scores_dn = []

for i in range(1,30,2):
    # instantiate learning model (k = 30)
    knn = KNeighborsClassifier(n_neighbors=i,algorithm='kd_tree')

    # fitting the model on crossvalidation train
    knn.fit(train_bow_dn, y_train)

    #ROC score of Train Data
    train_prob_dn = []
    for m in range(0,length[0],1000):
        train_prob_dn.extend(knn.predict_proba(train_bow_dn[m:m+1000]))

    train_prob2 = np.asarray(train_prob_dn)
    train_prob3 = train_prob2[:,1]
    scores_train_dn = roc_auc_score(y_train,train_prob3)
    roc_score_train_dn.append(scores_train_dn)

    cv_prob_dn = []
    for n in range(0,length1[0],1000):
        cv_prob_dn.extend(knn.predict_proba(cv_bow_dn[n:n+1000]))

    cv_prob2 = np.asarray(cv_prob_dn)
    cv_prob3 = cv_prob2[:,1]
    scores_cv_dn = roc_auc_score(y_cv,cv_prob3)
    roc_score_cv_dn.append(scores_cv_dn)

    print("For Hyperparameter value of K = ",i)
    print("AUC Score on Train Data: ",roc_score_train_dn[-1])
    print("AUC Score on CV Data: ",roc_score_cv_dn[-1])
    print("**************")

# open the file for writing an array to file to save on disk
fileObject = open("./train_scores_dn_to_file.pkl",'wb')
pickle.dump(roc_score_train_dn,fileObject)   # this writes the object a to the f
fileObject.close() # here we close the fileObject

# open the file for writing an array to file to save on disk
fileObject = open("./cv_scores_dn_to_file.pkl",'wb')
pickle.dump(roc_score_cv_dn,fileObject)   # this writes the object a to the file
fileObject.close() # here we close the fileObject
```

```
For Hyperparameter value of K =  1
AUC Score on Train Data:  1.0
AUC Score on CV Data:  0.49551638001514775
**************
For Hyperparameter value of K =  3
AUC Score on Train Data:  0.9115102651720306
AUC Score on CV Data:  0.5034575829460358
```

```
**************
For Hyperparameter value of K =  5
AUC Score on Train Data:  0.8561730942476127
AUC Score on CV Data:  0.5111056991439002
**************
For Hyperparameter value of K =  7
AUC Score on Train Data:  0.8179734292459959
AUC Score on CV Data:  0.508019909352201
**************
For Hyperparameter value of K =  9
AUC Score on Train Data:  0.785730831307097
AUC Score on CV Data:  0.5169106738670505
**************
For Hyperparameter value of K =  11
AUC Score on Train Data:  0.7633018049376674
AUC Score on CV Data:  0.5166531788314696
**************
For Hyperparameter value of K =  13
AUC Score on Train Data:  0.7450899554035945
AUC Score on CV Data:  0.5203270617580286
**************
For Hyperparameter value of K =  15
AUC Score on Train Data:  0.7322999720043843
AUC Score on CV Data:  0.526314456901308
**************
For Hyperparameter value of K =  17
AUC Score on Train Data:  0.7202128514110671
AUC Score on CV Data:  0.5283929393958482
**************
For Hyperparameter value of K =  19
AUC Score on Train Data:  0.7105580414185982
AUC Score on CV Data:  0.5325123411357321
**************
For Hyperparameter value of K =  21
AUC Score on Train Data:  0.7000323440871294
AUC Score on CV Data:  0.5307638341451801
**************
For Hyperparameter value of K =  23
AUC Score on Train Data:  0.6930678280215099
AUC Score on CV Data:  0.5302278314829627
**************
For Hyperparameter value of K =  25
AUC Score on Train Data:  0.6860674904472587
AUC Score on CV Data:  0.5284659905766051
**************
For Hyperparameter value of K =  27
AUC Score on Train Data:  0.6799127221431762
AUC Score on CV Data:  0.5271398107248056
**************
For Hyperparameter value of K =  29
AUC Score on Train Data:  0.6739163087001291
AUC Score on CV Data:  0.5308714912475035
**************
```

In [23]:
```
fileObject = open("./train_scores_dn_to_file.pkl",'rb') # we open the file for re
train_scores_dn = pickle.load(fileObject) # load the object from the file

fileObject = open("./cv_scores_dn_to_file.pkl",'rb') # we open the file for read
cv_scores_dn = pickle.load(fileObject) # load the object from the file
```

In [27]:
```
# creating odd list of K for KNN
myList = list(range(0,30))
neighbors = list(filter(lambda x: x % 2 != 0, myList))
neighbors
```

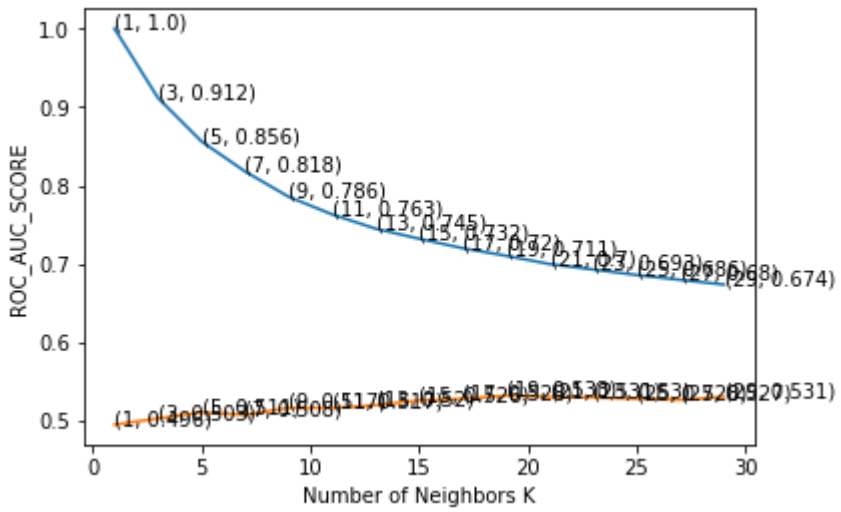
Out[27]:
```
[1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29]
```

In [28]:
```
plt.plot(neighbors, train_scores_dn)
plt.plot(neighbors, cv_scores_dn)

for xy in zip(neighbors, np.round(train_scores_dn,3)):
    plt.annotate('(%s, %s)' % xy, xy=xy, textcoords='data')
for xy in zip(neighbors, np.round(cv_scores_dn,3)):
    plt.annotate('(%s, %s)' % xy, xy=xy, textcoords='data')

plt.xlabel('Number of Neighbors K')
plt.ylabel('ROC_AUC_SCORE')

plt.show()
```



In [29]:
```
#Training KNN for best hyperparameter
knn = KNeighborsClassifier(19,algorithm='kd_tree')
knn.fit(train_bow_dn,y_train)
#pred = knn.predict(test_bow)
```

Out[29]:
```
KNeighborsClassifier(algorithm='kd_tree', leaf_size=30, metric='minkowski',
           metric_params=None, n_jobs=1, n_neighbors=19, p=2,
           weights='uniform')
```

In [ ]:
```
#finding roc_auc_score on test data
roc_score_test = []
length3 = (test_bow.shape)
pred_test = []
for i in range(0,length3[0],1000):
    pred_test.extend(knn.predict_proba(test_bow[i:i+1000]))

test_prob2 = np.asarray(pred_test)
test_prob3 = test_prob2[:,1]
scores_test = roc_auc_score(y_test,test_prob3)
roc_score_test.append(scores_test)

#second method
fpr, tpr, thresholds = roc_curve(y_test, test_prob3)
roc_auc = auc(fpr, tpr,reorder='deprecated')
#this will work
```

In [30]:
```
#finding roc_auc_score on test data
roc_score_test_dn = []
length3 = (test_bow_dn.shape)
pred_test_dn = []
for i in range(0,length3[0],1000):
    pred_test_dn.extend(knn.predict_proba(test_bow_dn[i:i+1000]))

test_prob2 = np.asarray(pred_test_dn)
test_prob3 = test_prob2[:,1]
scores_test_dn = roc_auc_score(y_test,test_prob3)
roc_score_test_dn.append(scores_test_dn)

#second method
fpr, tpr, thresholds = roc_curve(y_test, test_prob3)
roc_auc_dn = auc(fpr, tpr,reorder='deprecated')
```

In [32]:
```
print(roc_score_test_dn)
print(roc_auc_dn)
```

```
[0.5208303750208897]
0.5208303750208897
```

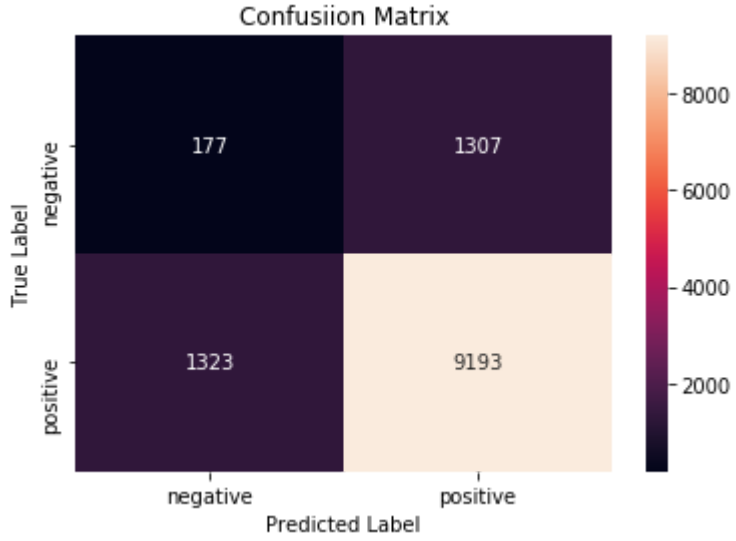
In [39]:
```
#defining own threshhold for prediction over probability values
def pred(y):
    y_pred = []
    for i in y:
        if i.all()>=0.5:
            y_pred.append(1)
        else:
            y_pred.append(0)
    return y_pred

y_pred_dn = pred(pred_test_dn)
```

In [40]:
```
# Confusion Matrix on Test Data
#y_pred_dn = np.argmax(pred_test_dn, axis=1)
cm_bow_dn = confusion_matrix(y_test, y_pred_dn)
cm_bow_dn
```

Out[40]:
```
array([[ 177, 1307],
       [1323, 9193]], dtype=int64)
```

In [41]:
```
# plot confusion matrix to describe the performance of classifier.
import seaborn as sns
class_label = ["negative", "positive"]
df_cm = pd.DataFrame(cm_bow_dn, index = class_label, columns = class_label)
sns.heatmap(df_cm, annot = True, fmt = "d")
plt.title("Confusiion Matrix")
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.show()
```



In [42]:
```
# To show main classification report
from sklearn.metrics import classification_report
print(classification_report(y_test, y_pred_dn))
```

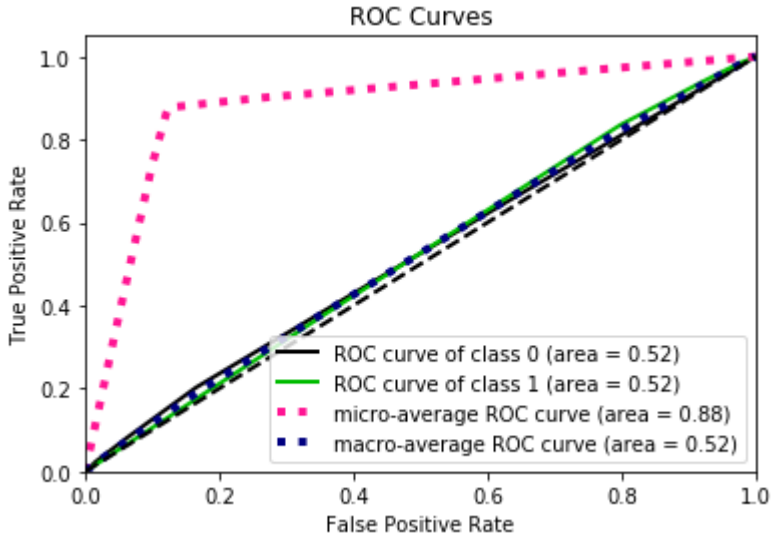
```
             precision    recall  f1-score   support

          0       0.12      0.12      0.12      1484
          1       0.88      0.87      0.87     10516

avg / total       0.78      0.78      0.78     12000
```

In [44]:
```
#Plotting ROC curve over Test Data
skplt.metrics.plot_roc_curve(y_test, pred_test_dn)
```

Out[44]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x16085951588>
```



TF-IDF

In [45]:
```
#tf-idf on train data
tf_idf_vect = TfidfVectorizer(ngram_range=(1,1)) #considering only uni-gram as I
train_tf_idf_nstd = tf_idf_vect.fit_transform(X_train[:,9]) #sparse matrix
cv_tfidf_nstd = tf_idf_vect.transform(X_cv[:,9])
test_tfidf_nstd = tf_idf_vect.transform(X_test[:,9])
print(train_tf_idf_nstd.shape)
print(cv_tfidf_nstd.shape)
print(test_tfidf_nstd.shape)
```

```
(38400, 37996)
(9600, 37996)
(12000, 37996)
```

In [46]:
```
# Column Standardization of the tfidf non-standard vector
std_scal = StandardScaler(with_mean=False)
std_scal.fit(train_tf_idf_nstd)
train_tfidf = std_scal.transform(train_tf_idf_nstd)
cv_tfidf = std_scal.transform(cv_tfidf_nstd)
test_tfidf = std_scal.transform(test_tfidf_nstd)
```

In [22]:
```
roc_score_train_tfidf = []
roc_score_cv_tfidf = []
length = (train_tfidf.shape)
length[0]
length1 = (cv_tfidf.shape)
length1[0]
cv_scores_tfidf = []
train_scores_tfidf = []

for i in range(1,30,2):
    # instantiate learning model (k = 30)
    knn_tfidf = KNeighborsClassifier(n_neighbors=i,algorithm='brute')

    # fitting the model on crossvalidation train
    knn_tfidf.fit(train_tfidf, y_train)

    #ROC score of Train Data
    train_prob_tfidf = []
    for m in range(0,length[0],1000):
        train_prob_tfidf.extend(knn_tfidf.predict_proba(train_tfidf[m:m+1000]))

    train_prob2 = np.asarray(train_prob_tfidf)
    train_prob3 = train_prob2[:,1]
    scores_train_tfidf = roc_auc_score(y_train,train_prob3)
    roc_score_train_tfidf.append(scores_train_tfidf)

    cv_prob_tfidf = []
    for n in range(0,length1[0],1000):
        cv_prob_tfidf.extend(knn_tfidf.predict_proba(cv_tfidf[n:n+1000]))

    cv_prob2 = np.asarray(cv_prob_tfidf)
    cv_prob3 = cv_prob2[:,1]
    scores_cv_tfidf = roc_auc_score(y_cv,cv_prob3)
    roc_score_cv_tfidf.append(scores_cv_tfidf)

    print("For Hyperparameter value of K = ",i)
    print("AUC Score on Train Data: ",roc_score_train_tfidf[-1])
    print("AUC Score on CV Data: ",roc_score_cv_tfidf[-1])
    print("**************")

# open the file for writing an array to fileto be save on disk
fileObject = open("./train_scores_tfidf_to_file.pkl",'wb')
pickle.dump(roc_score_train_tfidf,fileObject)   # this writes the object a to the
fileObject.close() # here we close the fileObject

# open the file for writing an array to fileto be save on disk
fileObject = open("./cv_scores_tfidf_to_file.pkl",'wb')
pickle.dump(roc_score_cv_tfidf,fileObject)   # this writes the object a to the f
fileObject.close() # here we close the fileObject
```

```
For Hyperparameter value of K =  1
AUC Score on Train Data:  1.0
AUC Score on CV Data:  0.555184563704417
**************
For Hyperparameter value of K =  3
AUC Score on Train Data:  0.9670363421050668
AUC Score on CV Data:  0.5821555992225445
```

```
**************
For Hyperparameter value of K =  5
AUC Score on Train Data:  0.953002289133024
AUC Score on CV Data:  0.5846116857607994
**************
For Hyperparameter value of K =  7
AUC Score on Train Data:  0.9438715462188633
AUC Score on CV Data:  0.5865619136254876
**************
For Hyperparameter value of K =  9
AUC Score on Train Data:  0.9351810021616954
AUC Score on CV Data:  0.5943882996082112
**************
For Hyperparameter value of K =  11
AUC Score on Train Data:  0.9269156050815093
AUC Score on CV Data:  0.6075837398448224
**************
For Hyperparameter value of K =  13
AUC Score on Train Data:  0.9189572853336189
AUC Score on CV Data:  0.6263439367883152
**************
For Hyperparameter value of K =  15
AUC Score on Train Data:  0.9128736923234395
AUC Score on CV Data:  0.6517652807453379
**************
For Hyperparameter value of K =  17
AUC Score on Train Data:  0.9113578720891845
AUC Score on CV Data:  0.6685468179725412
**************
For Hyperparameter value of K =  19
AUC Score on Train Data:  0.9163772588835241
AUC Score on CV Data:  0.6698058612988438
**************
For Hyperparameter value of K =  21
AUC Score on Train Data:  0.9204712414530333
AUC Score on CV Data:  0.6544432187387901
**************
For Hyperparameter value of K =  23
AUC Score on Train Data:  0.9219047559331385
AUC Score on CV Data:  0.640571795665471
**************
For Hyperparameter value of K =  25
AUC Score on Train Data:  0.9231248868821222
AUC Score on CV Data:  0.6240347308556875
**************
For Hyperparameter value of K =  27
AUC Score on Train Data:  0.9214103350593906
AUC Score on CV Data:  0.6131012830755044
**************
For Hyperparameter value of K =  29
AUC Score on Train Data:  0.9168202267983794
AUC Score on CV Data:  0.6000363284352033
**************
```

In [47]:
```
fileObject = open("./train_scores_tfidf_to_file.pkl",'rb') # we open the file for
train_scores_tfidf = pickle.load(fileObject) # load the object from the file

fileObject = open("./cv_scores_tfidf_to_file.pkl",'rb') # we open the file for re
cv_scores_tfidf = pickle.load(fileObject) # load the object from the file
```

In [48]:
```
# creating odd list of K for KNN
myList = list(range(0,30))
neighbors = list(filter(lambda x: x % 2 != 0, myList))
neighbors
```

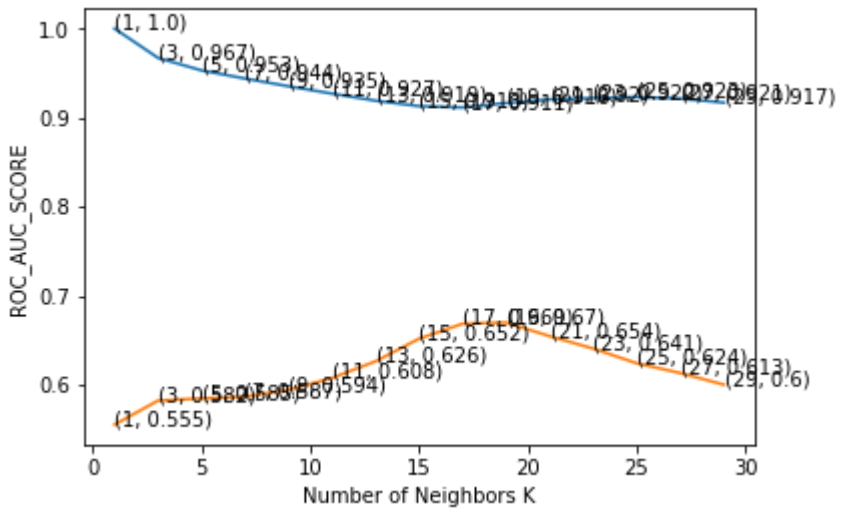
Out[48]:
```
[1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29]
```

In [49]:
```
plt.plot(neighbors, train_scores_tfidf)
plt.plot(neighbors, cv_scores_tfidf)

for xy in zip(neighbors, np.round(train_scores_tfidf,3)):
    plt.annotate('(%s, %s)' % xy, xy=xy, textcoords='data')
for xy in zip(neighbors, np.round(cv_scores_tfidf,3)):
    plt.annotate('(%s, %s)' % xy, xy=xy, textcoords='data')

plt.xlabel('Number of Neighbors K')
plt.ylabel('ROC_AUC_SCORE')

plt.show()
```



In [50]:
```
#Training KNN for best hyperparameter, K=19
knn_tfidf = KNeighborsClassifier(19,algorithm='brute')
knn_tfidf.fit(train_tfidf,y_train)
#pred = knn.predict(test_bow)
```

Out[50]:
```
KNeighborsClassifier(algorithm='brute', leaf_size=30, metric='minkowski',
           metric_params=None, n_jobs=1, n_neighbors=19, p=2,
           weights='uniform')
```

In [51]:
```
#finding roc_auc_score on test data
roc_score_test_tfidf = []
length3 = (test_tfidf.shape)
pred_test_tfidf = []
for i in range(0,length3[0],1000):
    pred_test_tfidf.extend(knn_tfidf.predict_proba(test_tfidf[i:i+1000]))

test_prob2 = np.asarray(pred_test_tfidf)
test_prob3 = test_prob2[:,1]
scores_test_tfidf = roc_auc_score(y_test,test_prob3)
roc_score_test_tfidf.append(scores_test_tfidf)

#second method
fpr, tpr, thresholds = roc_curve(y_test, test_prob3)
roc_auc_tfidf = auc(fpr, tpr,reorder='deprecated')
```

In [52]:
```
print(roc_score_test_tfidf)
print(roc_auc_tfidf)
```

```
[0.6179884791138444]
0.6179884791138444
```

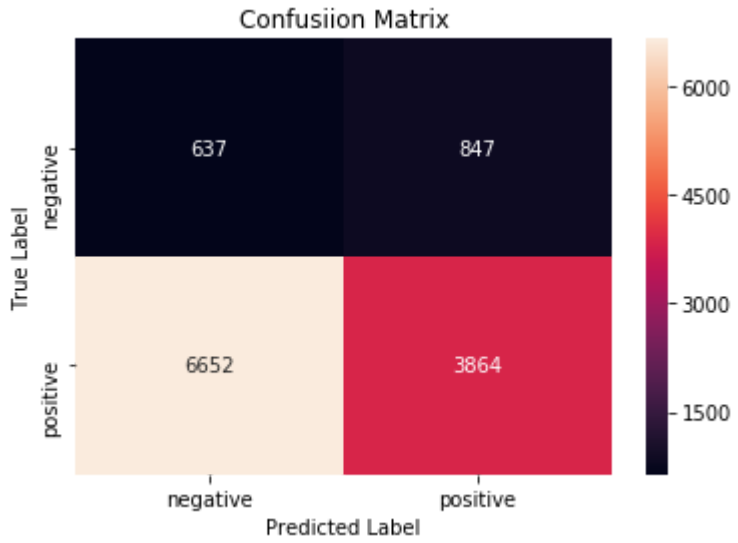
In [117]:
```
#defining own threshhold for prediction over probability values
def pred(y):
    y_pred = []
    for i in y:
        if i.all()>=0.5:
            y_pred.append(1)
        else:
            y_pred.append(0)
    return y_pred

y_pred_tfidf = pred(pred_test_tfidf)
```

In [118]:
```
# Confusion Matrix on Test Data
#y_pred_tfidf = np.argmax(pred_test_tfidf, axis=1)
cm_tfidf = confusion_matrix(y_test, y_pred_tfidf)
cm_tfidf
```

Out[118]:
```
array([[ 637,  847],
       [6652, 3864]], dtype=int64)
```

In [119]:
```
# plot confusion matrix to describe the performance of classifier.
import seaborn as sns
class_label = ["negative", "positive"]
df_cm = pd.DataFrame(cm_tfidf, index = class_label, columns = class_label)
sns.heatmap(df_cm, annot = True, fmt = "d")
plt.title("Confusiion Matrix")
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.show()
```



In [120]:
```
# To show main classification report
from sklearn.metrics import classification_report
print(classification_report(y_test, y_pred_tfidf))
```

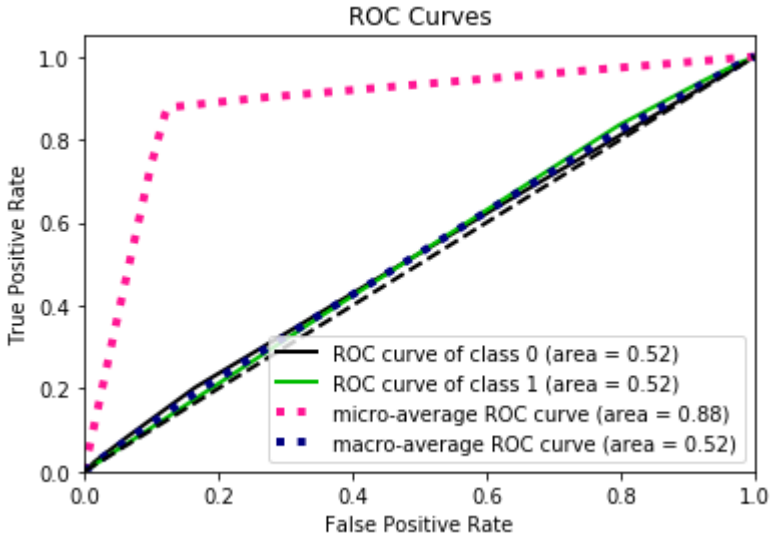
```
             precision    recall  f1-score   support

          0       0.09      0.43      0.15      1484
          1       0.82      0.37      0.51     10516

avg / total       0.73      0.38      0.46     12000
```

In [121]:
```
#Plotting ROC curve over Test Data
skplt.metrics.plot_roc_curve(y_test, pred_test_dn)
```

Out[121]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x160d7d96c88>
```



TF-IDF - KD-Tree

In [62]:
```
svd = TruncatedSVD()
train_tfidf_dn = svd.fit_transform(train_tfidf)
cv_tfidf_dn = svd.transform(cv_tfidf)
test_tfidf_dn = svd.transform(test_tfidf)
#X_tr_input = X_tr_input1
#x_cv_input = x_cv_input1
```

In [34]:
```
roc_score_train_tfidf_dn = []
roc_score_cv_tfidf_dn = []
length = (train_tfidf_dn.shape)

length[0]
length1 = (cv_tfidf_dn.shape)
length1[0]
cv_scores_tfidf_dn = []
train_scores_tfidf_dn = []

for i in range(1,30,2):
    # instantiate learning model (k = 30)
    knn_tfidf_dn = KNeighborsClassifier(n_neighbors=i,algorithm='kd_tree')

    # fitting the model on crossvalidation train
    knn_tfidf_dn.fit(train_tfidf_dn, y_train)

    #ROC score of Train Data
    train_prob_tfidf_dn = []
    for m in range(0,length[0],1000):
        train_prob_tfidf_dn.extend(knn_tfidf_dn.predict_proba(train_tfidf_dn[m:m

    train_prob2 = np.asarray(train_prob_tfidf_dn)
    train_prob3 = train_prob2[:,1]
    scores_train_tfidf_dn = roc_auc_score(y_train,train_prob3)
    roc_score_train_tfidf_dn.append(scores_train_tfidf_dn)

    cv_prob_tfidf_dn = []
    for n in range(0,length1[0],1000):
        cv_prob_tfidf_dn.extend(knn_tfidf_dn.predict_proba(cv_tfidf_dn[n:n+1000]

    cv_prob2 = np.asarray(cv_prob_tfidf_dn)
    cv_prob3 = cv_prob2[:,1]
    scores_cv_tfidf_dn = roc_auc_score(y_cv,cv_prob3)
    roc_score_cv_tfidf_dn.append(scores_cv_tfidf_dn)

    print("For Hyperparameter value of K = ",i)
    print("AUC Score on Train Data: ",roc_score_train_tfidf_dn[-1])
    print("AUC Score on CV Data: ",roc_score_cv_tfidf_dn[-1])
    print("**************")

# open the file for writing an array to fileto be save on disk
fileObject = open("./train_scores_tfidf_dn_to_file.pkl",'wb')
pickle.dump(roc_score_train_tfidf_dn,fileObject)   # this writes the object a to
fileObject.close() # here we close the fileObject

# open the file for writing an array to fileto be save on disk
fileObject = open("./cv_scores_tfidf_dn_to_file.pkl",'wb')
pickle.dump(roc_score_cv_tfidf_dn,fileObject)   # this writes the object a to th
fileObject.close() # here we close the fileObject
```

```
For Hyperparameter value of K =  1
AUC Score on Train Data:  1.0
AUC Score on CV Data:  0.4933721099515735
**************
For Hyperparameter value of K =  3
AUC Score on Train Data:  0.9087892540219125
```

```
AUC Score on CV Data:  0.4890540484310651
**************
For Hyperparameter value of K =  5
AUC Score on Train Data:  0.8517275565657175
AUC Score on CV Data:  0.49804531020239645
**************
For Hyperparameter value of K =  7
AUC Score on Train Data:  0.8116651460008636
AUC Score on CV Data:  0.5002006832153186
**************
For Hyperparameter value of K =  9
AUC Score on Train Data:  0.7793618457041643
AUC Score on CV Data:  0.5042022587964673
**************
For Hyperparameter value of K =  11
AUC Score on Train Data:  0.7576119265389624
AUC Score on CV Data:  0.5046958730959868
**************
For Hyperparameter value of K =  13
AUC Score on Train Data:  0.7412397211013054
AUC Score on CV Data:  0.4998390591173944
**************
For Hyperparameter value of K =  15
AUC Score on Train Data:  0.7267563249416531
AUC Score on CV Data:  0.4986177346891107
**************
For Hyperparameter value of K =  17
AUC Score on Train Data:  0.7153008715245274
AUC Score on CV Data:  0.5055196185483174
**************
For Hyperparameter value of K =  19
AUC Score on Train Data:  0.705003887526767
AUC Score on CV Data:  0.5101569158040522
**************
For Hyperparameter value of K =  21
AUC Score on Train Data:  0.6961319413705378
AUC Score on CV Data:  0.5083579267120255
**************
For Hyperparameter value of K =  23
AUC Score on Train Data:  0.6892986556003772
AUC Score on CV Data:  0.5133784313690901
**************
For Hyperparameter value of K =  25
AUC Score on Train Data:  0.683480444757465
AUC Score on CV Data:  0.519268130934695
**************
For Hyperparameter value of K =  27
AUC Score on Train Data:  0.6762111696405513
AUC Score on CV Data:  0.5183883519062156
**************
For Hyperparameter value of K =  29
AUC Score on Train Data:  0.6732037118254701
AUC Score on CV Data:  0.517054960325634
**************
```

In [63]:
```
fileObject = open("./train_scores_tfidf_dn_to_file.pkl",'rb') # we open the file
train_scores_tfidf_dn = pickle.load(fileObject) # load the object from the file

fileObject = open("./cv_scores_tfidf_dn_to_file.pkl",'rb') # we open the file fo
cv_scores_tfidf_dn = pickle.load(fileObject) # load the object from the file
```

In [64]:
```
# creating odd list of K for KNN
myList = list(range(0,30))
neighbors = list(filter(lambda x: x % 2 != 0, myList))
neighbors
```

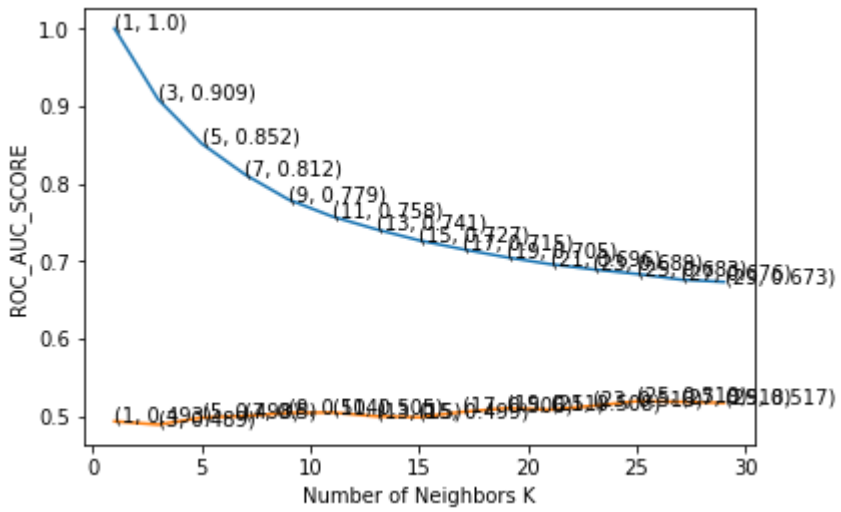
Out[64]:
```
[1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29]
```

In [65]:
```
plt.plot(neighbors, train_scores_tfidf_dn)
plt.plot(neighbors, cv_scores_tfidf_dn)

for xy in zip(neighbors, np.round(train_scores_tfidf_dn,3)):
    plt.annotate('(%s, %s)' % xy, xy=xy, textcoords='data')
for xy in zip(neighbors, np.round(cv_scores_tfidf_dn,3)):
    plt.annotate('(%s, %s)' % xy, xy=xy, textcoords='data')

plt.xlabel('Number of Neighbors K')
plt.ylabel('ROC_AUC_SCORE')

plt.show()
```



In [66]:
```
#Training KNN for best hyperparameter K=25
knn_tfidf_dn = KNeighborsClassifier(25,algorithm='kd_tree')
knn_tfidf_dn.fit(train_tfidf_dn,y_train)
#pred = knn.predict(test_bow)
```

Out[66]:
```
KNeighborsClassifier(algorithm='kd_tree', leaf_size=30, metric='minkowski',
           metric_params=None, n_jobs=1, n_neighbors=25, p=2,
           weights='uniform')
```

In [67]:
```
#finding roc_auc_score on test data
roc_score_test_tfidf_dn = []
length3 = (test_tfidf_dn.shape)
pred_test_tfidf_dn = []
for i in range(0,length3[0],1000):
    pred_test_tfidf_dn.extend(knn_tfidf_dn.predict_proba(test_tfidf_dn[i:i+1000])

test_prob2 = np.asarray(pred_test_tfidf_dn)
test_prob3 = test_prob2[:,1]
scores_test_tfidf_dn = roc_auc_score(y_test,test_prob3)
roc_score_test_tfidf_dn.append(scores_test_tfidf_dn)

#second method
fpr, tpr, thresholds = roc_curve(y_test, test_prob3)
roc_auc_tfidf_dn = auc(fpr, tpr,reorder='deprecated')
```

In [68]:
```
print(roc_score_test_tfidf_dn)
print(roc_auc_tfidf_dn)
```

```
[0.5197627232639468]
0.5197627232639468
```

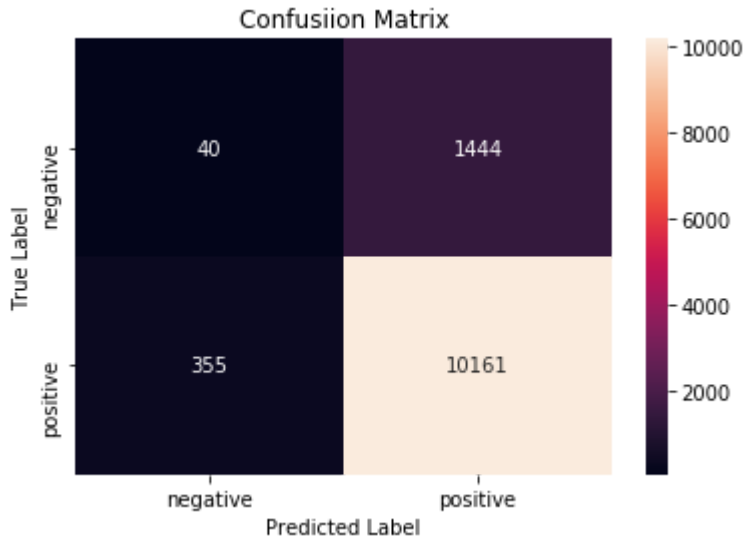
In [112]:
```
#defining own threshhold for prediction over probability values
def pred(y):
    y_pred = []
    for i in y:
        if i.all()>=0.5:
            y_pred.append(1)
        else:
            y_pred.append(0)
    return y_pred

y_pred_tfidf_dn = pred(pred_test_tfidf_dn)
```

In [113]:
```
# Confusion Matrix on Test Data
#y_pred_tfidf_dn = np.argmax(pred_test_tfidf_dn, axis=1)
cm_tfidf_dn = confusion_matrix(y_test, y_pred_tfidf_dn)
cm_tfidf_dn
```

Out[113]:
```
array([[   40,  1444],
       [  355, 10161]], dtype=int64)
```

In [114]:
```
# plot confusion matrix to describe the performance of classifier.
import seaborn as sns
class_label = ["negative", "positive"]
df_cm = pd.DataFrame(cm_tfidf_dn, index = class_label, columns = class_label)
sns.heatmap(df_cm, annot = True, fmt = "d")
plt.title("Confusiion Matrix")
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.show()
```



In [115]:
```
# To show main classification report
from sklearn.metrics import classification_report
print(classification_report(y_test, y_pred_tfidf_dn))
```

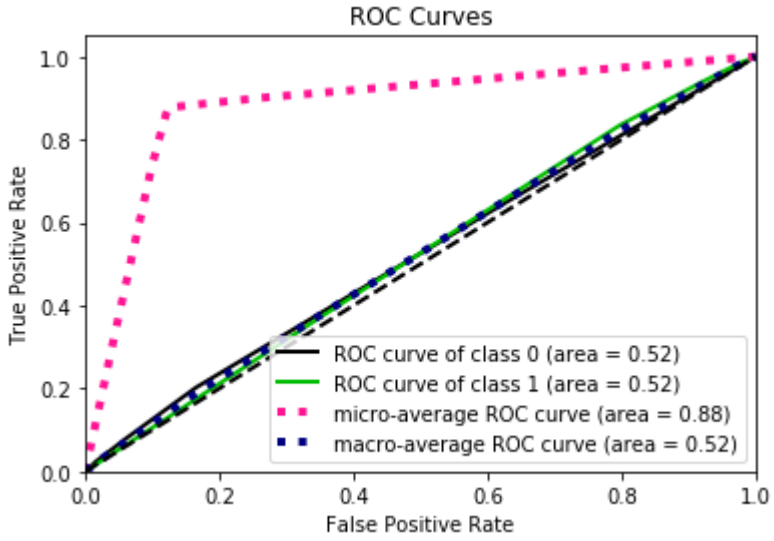
```
             precision    recall  f1-score   support

          0       0.10      0.03      0.04      1484
          1       0.88      0.97      0.92     10516

avg / total       0.78      0.85      0.81     12000
```

In [122]:
```
#Plotting ROC curve over Test Data
skplt.metrics.plot_roc_curve(y_test, pred_test_dn)
```

Out[122]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x160d0dbeeb8>
```



Avg W2V

In [123]:
```
fileObject = open("./final_to_file2.pkl",'rb') # we open the file for reading
final = pickle.load(fileObject) # load the object from the file
```

In [124]:
```
#w2v
# Train your own Word2Vec model using your own text corpus
i=0
list_of_sent=[]
for sent in final['CleanedText'].values:
    list_of_sent.append(sent.split())

print(type(list_of_sent))
print(final['CleanedText'].values[0])
print("**********************************************************************")
print(list_of_sent[0])
```

```
<class 'list'>
witti littl book make son laugh loud recit car drive along alway sing refrain h
es learn whale india droop love new word book introduc silli classic book will
bet son still abl recit memori colleg
**********************************************************************
['witti', 'littl', 'book', 'make', 'son', 'laugh', 'loud', 'recit', 'car', 'dri
ve', 'along', 'alway', 'sing', 'refrain', 'hes', 'learn', 'whale', 'india', 'dr
oop', 'love', 'new', 'word', 'book', 'introduc', 'silli', 'classic', 'book', 'w
ill', 'bet', 'son', 'still', 'abl', 'recit', 'memori', 'colleg']
```

In [125]:
```
w2v_model=Word2Vec(list_of_sent,min_count=5,size=50, workers=4)
w2v_words = list(w2v_model.wv.vocab)
```

In [126]:
```
# average Word2Vec
# compute average word2vec for each review.
sent_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sent in list_of_sent: # for each review/sentence
    sent_vec = np.zeros(50) # as word vectors are of zero length
    cnt_words =0; # num of words with a valid vector in the sentence/review
    for word in sent: # for each word in a review/sentence
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    sent_vectors.append(sent_vec)
print(len(sent_vectors))
#print(len(sent_vectors[0]))
print(type(sent_vectors))
```

```
60000
<class 'list'>
```

In [127]:
```
# create design matrix X and target vector y
X = np.array(sent_vectors[::]) # end index is exclusive
y = np.array(final['Score']) # showing you two ways of indexing a pandas df
```

In [93]:
```
X_train_nstd = X[0:38400:1]
X_cv_nstd = X[38400:48000:1]
X_test_nstd = X[48000:60000:1]

y_train_nstd = y[0:38400:1]
y_cv_nstd = y[38400:48000:1]
y_test_nstd =y[48000:60000:1]

print(X_train_nstd.shape)
print(X_cv_nstd.shape)
print(X_test_nstd.shape)
print(y_train_nstd.shape)
print(y_cv_nstd.shape)
print(y_test_nstd.shape)
```

```
(38400, 50)
(9600, 50)
(12000, 50)
(38400,)
(9600,)
(12000,)
```

In [94]:
```
# Column Standardization of the tfidf non-standard vector
std_scal = StandardScaler(with_mean=False)
std_scal.fit(X_train_nstd)
train_avgw2v = std_scal.transform(X_train_nstd)
cv_avgw2v = std_scal.transform(X_cv_nstd)
test_avgw2v = std_scal.transform(X_test_nstd)
```

In [132]:
```
roc_score_train_avgw2v = []
roc_score_cv_avgw2v = []
length = (train_avgw2v.shape)
length[0]
length1 = (cv_avgw2v.shape)
length1[0]
cv_scores_avgw2v = []
train_scores_avgw2v = []

for i in range(1,30,2):
    # instantiate learning model (k = 30)
    knn_avgw2v = KNeighborsClassifier(n_neighbors=i,algorithm='brute')

    # fitting the model on crossvalidation train
    knn_avgw2v.fit(train_avgw2v, y_train)

    #ROC score of Train Data
    train_prob_avgw2v = []
    for m in range(0,length[0],1000):
        train_prob_avgw2v.extend(knn_avgw2v.predict_proba(train_avgw2v[m:m+1000])

    train_prob2 = np.asarray(train_prob_avgw2v)
    train_prob3 = train_prob2[:,1]
    scores_train_avgw2v = roc_auc_score(y_train,train_prob3)
    roc_score_train_avgw2v.append(scores_train_avgw2v)

    cv_prob_avgw2v = []
    for n in range(0,length1[0],1000):
        cv_prob_avgw2v.extend(knn_avgw2v.predict_proba(cv_avgw2v[n:n+1000]))

    cv_prob2 = np.asarray(cv_prob_avgw2v)
    cv_prob3 = cv_prob2[:,1]
    scores_cv_avgw2v = roc_auc_score(y_cv,cv_prob3)
    roc_score_cv_avgw2v.append(scores_cv_avgw2v)

    print("For Hyperparameter value of K = ",i)
    print("AUC Score on Train Data: ",roc_score_train_avgw2v[-1])
    print("AUC Score on CV Data: ",roc_score_cv_avgw2v[-1])
    print("**************")

# open the file for writing an array to fileto be save on disk
fileObject = open("./train_scores_avgw2v_to_file.pkl",'wb')
pickle.dump(roc_score_train_avgw2v,fileObject)   # this writes the object a to t
fileObject.close() # here we close the fileObject

# open the file for writing an array to fileto be save on disk
fileObject = open("./cv_scores_avgw2v_to_file.pkl",'wb')
pickle.dump(roc_score_cv_avgw2v,fileObject)   # this writes the object a to the
fileObject.close() # here we close the fileObject
```

```
For Hyperparameter value of K =  1
AUC Score on Train Data:  1.0
AUC Score on CV Data:  0.6416273584905661
**************
For Hyperparameter value of K =  3
AUC Score on Train Data:  0.964066242891489
AUC Score on CV Data:  0.7308336316543127
```

```
**************
For Hyperparameter value of K =  5
AUC Score on Train Data:  0.9464236381823733
AUC Score on CV Data:  0.7643713675033692
**************
For Hyperparameter value of K =  7
AUC Score on Train Data:  0.9358948369541233
AUC Score on CV Data:  0.7849649911556604
**************
For Hyperparameter value of K =  9
AUC Score on Train Data:  0.9282529852442469
AUC Score on CV Data:  0.7991199882075471
**************
For Hyperparameter value of K =  11
AUC Score on Train Data:  0.922490903521363
AUC Score on CV Data:  0.8105407681940702
**************
For Hyperparameter value of K =  13
AUC Score on Train Data:  0.9176386638037617
AUC Score on CV Data:  0.8198501726752022
**************
For Hyperparameter value of K =  15
AUC Score on Train Data:  0.9144075806002088
AUC Score on CV Data:  0.8256618514150944
**************
For Hyperparameter value of K =  17
AUC Score on Train Data:  0.910765622899156
AUC Score on CV Data:  0.8302847035040432
**************
For Hyperparameter value of K =  19
AUC Score on Train Data:  0.909153710900923
AUC Score on CV Data:  0.8334993050876013
**************
For Hyperparameter value of K =  21
AUC Score on Train Data:  0.9066973370304464
AUC Score on CV Data:  0.834989786893531
**************
For Hyperparameter value of K =  23
AUC Score on Train Data:  0.9044148532452696
AUC Score on CV Data:  0.8400440111185985
**************
For Hyperparameter value of K =  25
AUC Score on Train Data:  0.9036159656880308
AUC Score on CV Data:  0.8429706978605122
**************
For Hyperparameter value of K =  27
AUC Score on Train Data:  0.9024002038142251
AUC Score on CV Data:  0.8440122241408354
**************
For Hyperparameter value of K =  29
AUC Score on Train Data:  0.9008241252879988
AUC Score on CV Data:  0.8462867461253369
**************
```

In [95]:
```
fileObject = open("./train_scores_avgw2v_to_file.pkl",'rb') # we open the file fo
train_scores_avgw2v = pickle.load(fileObject) # load the object from the file

fileObject = open("./cv_scores_avgw2v_to_file.pkl",'rb') # we open the file for r
cv_scores_avgw2v = pickle.load(fileObject) # load the object from the file
```

In [96]:
```
# creating odd list of K for KNN
myList = list(range(0,30))
neighbors = list(filter(lambda x: x % 2 != 0, myList))
neighbors
```

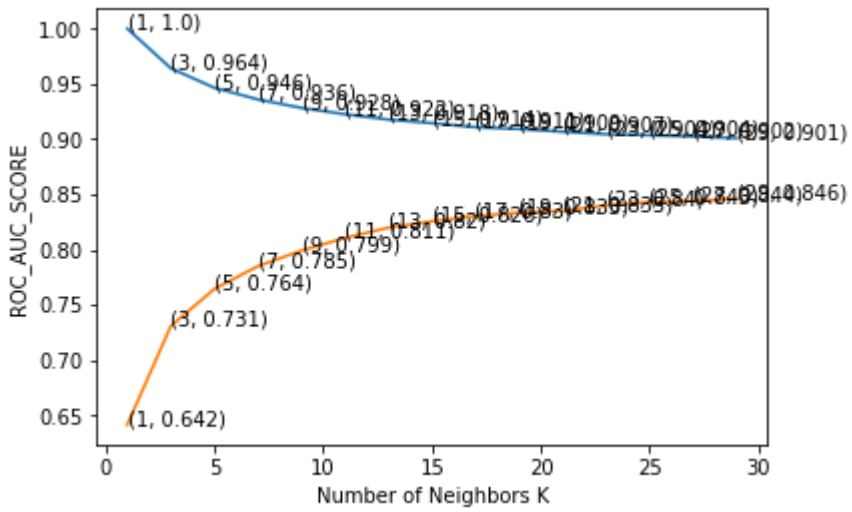
Out[96]:
```
[1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29]
```

In [97]:
```
plt.plot(neighbors, train_scores_avgw2v)
plt.plot(neighbors, cv_scores_avgw2v)

for xy in zip(neighbors, np.round(train_scores_avgw2v,3)):
    plt.annotate('(%s, %s)' % xy, xy=xy, textcoords='data')
for xy in zip(neighbors, np.round(cv_scores_avgw2v,3)):
    plt.annotate('(%s, %s)' % xy, xy=xy, textcoords='data')

plt.xlabel('Number of Neighbors K')
plt.ylabel('ROC_AUC_SCORE')

plt.show()
```



In [98]:
```
#Training KNN for best hyperparameter, K=29
knn_avgw2v = KNeighborsClassifier(29,algorithm='brute')
knn_avgw2v.fit(train_avgw2v,y_train)
#pred = knn.predict(test_bow)
```

Out[98]:
```
KNeighborsClassifier(algorithm='brute', leaf_size=30, metric='minkowski',
           metric_params=None, n_jobs=1, n_neighbors=29, p=2,
           weights='uniform')
```

In [99]:
```
#finding roc_auc_score on test data
roc_score_test_avgw2v = []
length3 = (test_avgw2v.shape)
pred_test_avgw2v = []
for i in range(0,length3[0],1000):
    pred_test_avgw2v.extend(knn_avgw2v.predict_proba(test_avgw2v[i:i+1000]))

test_prob2 = np.asarray(pred_test_avgw2v)
test_prob3 = test_prob2[:,1]
scores_test_avgw2v = roc_auc_score(y_test,test_prob3)
roc_score_test_avgw2v.append(scores_test_avgw2v)

#second method
fpr, tpr, thresholds = roc_curve(y_test, test_prob3)
roc_auc_avgw2v = auc(fpr, tpr,reorder='deprecated')
```

In [100]:
```
print(roc_score_test_avgw2v)
print(roc_auc_avgw2v)
```

```
[0.8041281787013806]
0.8041281787013806
```

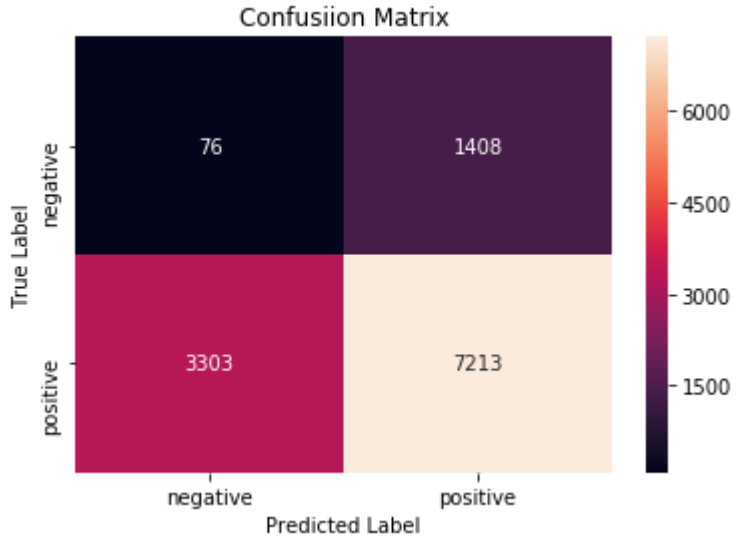
In [107]:
```
#defining own threshhold for prediction over probability values
def pred(y):
    y_pred = []
    for i in y:
        if i.all()>=0.5:
            y_pred.append(1)
        else:
            y_pred.append(0)
    return y_pred

y_pred_avgw2v = pred(pred_test_avgw2v)
```

In [108]:
```
# Confusion Matrix on Test Data
#y_pred_avgw2v = np.argmax(pred_test_avgw2v, axis=1)
cm_avgw2v = confusion_matrix(y_test, y_pred_avgw2v)
cm_avgw2v
```

Out[108]:
```
array([[  76, 1408],
       [3303, 7213]], dtype=int64)
```

In [109]:
```
# plot confusion matrix to describe the performance of classifier.
import seaborn as sns
class_label = ["negative", "positive"]
df_cm = pd.DataFrame(cm_avgw2v, index = class_label, columns = class_label)
sns.heatmap(df_cm, annot = True, fmt = "d")
plt.title("Confusiion Matrix")
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.show()
```



In [110]:
```
# To show main classification report
from sklearn.metrics import classification_report
print(classification_report(y_test, y_pred_avgw2v))
```

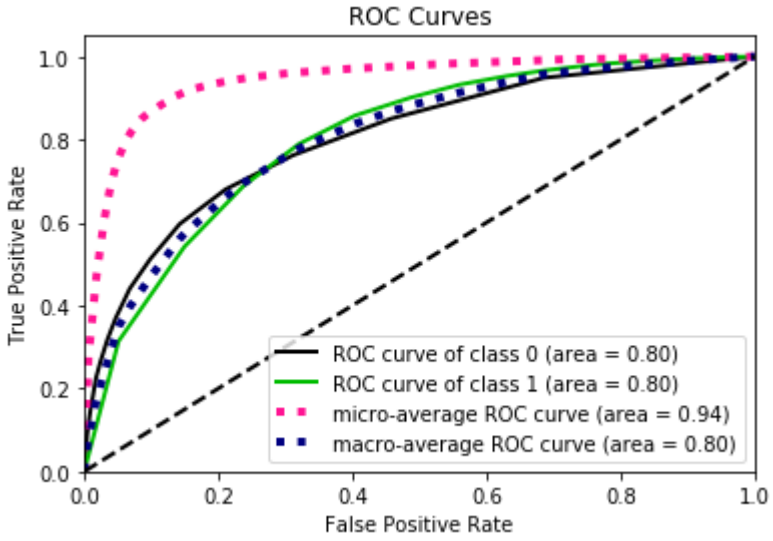
```
             precision    recall  f1-score   support

          0       0.02      0.05      0.03      1484
          1       0.84      0.69      0.75     10516

avg / total       0.74      0.61      0.66     12000
```

In [128]:
```
#Plotting ROC curve over Test Data
skplt.metrics.plot_roc_curve(y_test, pred_test_avgw2v)
```

Out[128]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x160937dbda0>
```



Avg W2V KD-Tree

In [129]:
```
svd = TruncatedSVD()
train_avgw2v_dn = svd.fit_transform(train_avgw2v)
cv_avgw2v_dn = svd.transform(cv_avgw2v)
test_avgw2v_dn = svd.transform(test_avgw2v)
#X_tr_input = X_tr_input1
#x_cv_input = x_cv_input1
```

In [146]:
```
roc_score_train_avgw2v_dn = []
roc_score_cv_avgw2v_dn = []
length = (train_avgw2v_dn.shape)

length[0]
length1 = (cv_avgw2v_dn.shape)
length1[0]
cv_scores_avgw2v_dn = []
train_scores_avgw2v_dn = []

for i in range(1,30,2):
    # instantiate learning model (k = 30)
    knn_avgw2v_dn = KNeighborsClassifier(n_neighbors=i,algorithm='kd_tree')

    # fitting the model on crossvalidation train
    knn_avgw2v_dn.fit(train_avgw2v_dn, y_train)

    #ROC score of Train Data
    train_prob_avgw2v_dn = []
    for m in range(0,length[0],1000):
        train_prob_avgw2v_dn.extend(knn_avgw2v_dn.predict_proba(train_avgw2v_dn[m

    train_prob2 = np.asarray(train_prob_avgw2v_dn)
    train_prob3 = train_prob2[:,1]
    scores_train_avgw2v_dn = roc_auc_score(y_train,train_prob3)
    roc_score_train_avgw2v_dn.append(scores_train_avgw2v_dn)

    cv_prob_avgw2v_dn = []
    for n in range(0,length1[0],1000):
        cv_prob_avgw2v_dn.extend(knn_avgw2v_dn.predict_proba(cv_avgw2v_dn[n:n+100

    cv_prob2 = np.asarray(cv_prob_avgw2v_dn)
    cv_prob3 = cv_prob2[:,1]
    scores_cv_avgw2v_dn = roc_auc_score(y_cv,cv_prob3)
    roc_score_cv_avgw2v_dn.append(scores_cv_avgw2v_dn)

    print("For Hyperparameter value of K = ",i)
    print("AUC Score on Train Data: ",roc_score_train_avgw2v_dn[-1])
    print("AUC Score on CV Data: ",roc_score_cv_avgw2v_dn[-1])
    print("**************")

# open the file for writing an array to fileto be save on disk
fileObject = open("./train_scores_avgw2v_dn_to_file.pkl",'wb')
pickle.dump(roc_score_train_avgw2v_dn,fileObject)   # this writes the object a to
fileObject.close() # here we close the fileObject

# open the file for writing an array to fileto be save on disk
fileObject = open("./cv_scores_avgw2v_dn_to_file.pkl",'wb')
pickle.dump(roc_score_cv_avgw2v_dn,fileObject)   # this writes the object a to t
fileObject.close() # here we close the fileObject
```

```
For Hyperparameter value of K =  1
AUC Score on Train Data:  1.0
AUC Score on CV Data:  0.5102847035040431
**************
For Hyperparameter value of K =  3
AUC Score on Train Data:  0.9146414587470505
```

```
AUC Score on CV Data:  0.5275750715970351
**************
For Hyperparameter value of K =  5
AUC Score on Train Data:  0.8604265365575459
AUC Score on CV Data:  0.5506808035714287
**************
For Hyperparameter value of K =  7
AUC Score on Train Data:  0.8229644428708135
AUC Score on CV Data:  0.5545577303739893
**************
For Hyperparameter value of K =  9
AUC Score on Train Data:  0.7954907378966447
AUC Score on CV Data:  0.559232542958221
**************
For Hyperparameter value of K =  11
AUC Score on Train Data:  0.7755707409764393
AUC Score on CV Data:  0.5653790431266846
**************
For Hyperparameter value of K =  13
AUC Score on Train Data:  0.7609146922360566
AUC Score on CV Data:  0.5705514551044475
**************
For Hyperparameter value of K =  15
AUC Score on Train Data:  0.7486276165128228
AUC Score on CV Data:  0.5773351162398922
**************
For Hyperparameter value of K =  17
AUC Score on Train Data:  0.7370541073407406
AUC Score on CV Data:  0.5790633423180593
**************
For Hyperparameter value of K =  19
AUC Score on Train Data:  0.7307047557645179
AUC Score on CV Data:  0.5742046411725068
**************
For Hyperparameter value of K =  21
AUC Score on Train Data:  0.7218125444622214
AUC Score on CV Data:  0.5742898732311322
**************
For Hyperparameter value of K =  23
AUC Score on Train Data:  0.7152037555774599
AUC Score on CV Data:  0.5732473466981133
**************
For Hyperparameter value of K =  25
AUC Score on Train Data:  0.7101207237201224
AUC Score on CV Data:  0.5755266067216981
**************
For Hyperparameter value of K =  27
AUC Score on Train Data:  0.7051037911637812
AUC Score on CV Data:  0.575726236101752
**************
For Hyperparameter value of K =  29
AUC Score on Train Data:  0.7013976283083255
AUC Score on CV Data:  0.5810107290262804
**************
```

In [130]:
```
fileObject = open("./train_scores_avgw2v_dn_to_file.pkl",'rb') # we open the file
train_scores_avgw2v_dn = pickle.load(fileObject) # load the object from the file

fileObject = open("./cv_scores_avgw2v_dn_to_file.pkl",'rb') # we open the file f
cv_scores_avgw2v_dn = pickle.load(fileObject) # load the object from the file
```

In [131]:
```
# creating odd list of K for KNN
myList = list(range(0,30))
neighbors = list(filter(lambda x: x % 2 != 0, myList))
neighbors
```

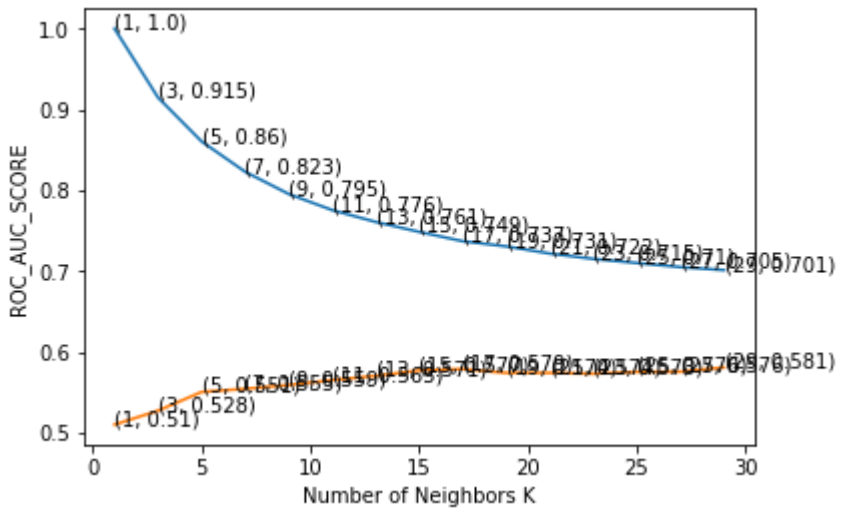
Out[131]:
```
[1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29]
```

In [132]:
```
plt.plot(neighbors, train_scores_avgw2v_dn)
plt.plot(neighbors, cv_scores_avgw2v_dn)

for xy in zip(neighbors, np.round(train_scores_avgw2v_dn,3)):
    plt.annotate('(%s, %s)' % xy, xy=xy, textcoords='data')
for xy in zip(neighbors, np.round(cv_scores_avgw2v_dn,3)):
    plt.annotate('(%s, %s)' % xy, xy=xy, textcoords='data')

plt.xlabel('Number of Neighbors K')
plt.ylabel('ROC_AUC_SCORE')

plt.show()
```



In [133]:
```
#Training KNN for best hyperparameter K=29
knn_avgw2v_dn = KNeighborsClassifier(29,algorithm='kd_tree')
knn_avgw2v_dn.fit(train_avgw2v_dn,y_train)
#pred = knn.predict(test_bow)
```

Out[133]:
```
KNeighborsClassifier(algorithm='kd_tree', leaf_size=30, metric='minkowski',
           metric_params=None, n_jobs=1, n_neighbors=29, p=2,
           weights='uniform')
```

In [134]:
```
#finding roc_auc_score on test data
roc_score_test_avgw2v_dn = []
length3 = (test_avgw2v_dn.shape)
pred_test_avgw2v_dn = []
for i in range(0,length3[0],1000):
    pred_test_avgw2v_dn.extend(knn_avgw2v_dn.predict_proba(test_avgw2v_dn[i:i+10

test_prob2 = np.asarray(pred_test_avgw2v_dn)
test_prob3 = test_prob2[:,1]
scores_test_avgw2v_dn = roc_auc_score(y_test,test_prob3)
roc_score_test_avgw2v_dn.append(scores_test_avgw2v_dn)

#second method
fpr, tpr, thresholds = roc_curve(y_test, test_prob3)
roc_auc_avgw2v_dn = auc(fpr, tpr,reorder='deprecated')
```

In [135]:
```
print(roc_score_test_avgw2v_dn)
print(roc_auc_avgw2v_dn)
```

```
[0.5260885671327173]
0.5260885671327173
```

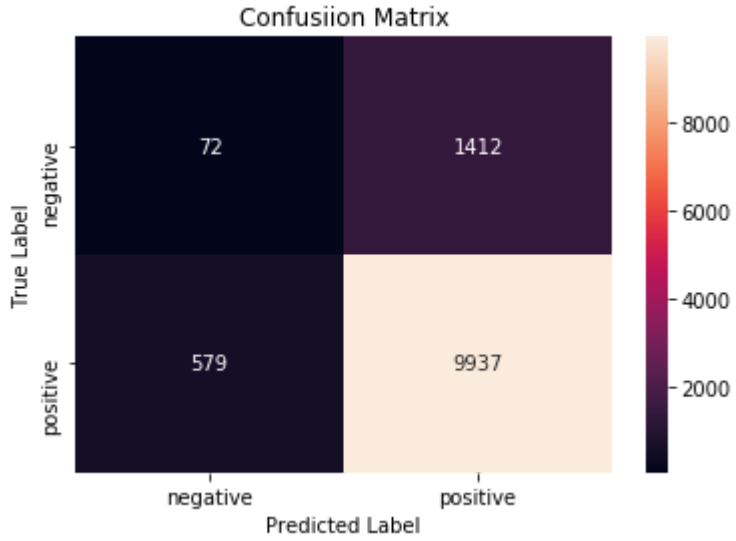
In [137]:
```
#defining own threshhold for prediction over probability values
def pred(y):
    y_pred = []
    for i in y:
        if i.all()>=0.5:
            y_pred.append(1)
        else:
            y_pred.append(0)
    return y_pred

y_pred_avgw2v_dn = pred(pred_test_avgw2v_dn)
```

In [138]:
```
# Confusion Matrix on Test Data
#y_pred_avgw2v_dn = np.argmax(pred_test_avgw2v_dn, axis=1)
cm_avgw2v_dn = confusion_matrix(y_test, y_pred_avgw2v_dn)
cm_avgw2v_dn
```

Out[138]:
```
array([[  72, 1412],
       [ 579, 9937]], dtype=int64)
```

In [139]:
```
# plot confusion matrix to describe the performance of classifier.
import seaborn as sns
class_label = ["negative", "positive"]
df_cm = pd.DataFrame(cm_avgw2v_dn, index = class_label, columns = class_label)
sns.heatmap(df_cm, annot = True, fmt = "d")
plt.title("Confusiion Matrix")
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.show()
```



In [140]:
```
# To show main classification report
from sklearn.metrics import classification_report
print(classification_report(y_test, y_pred_avgw2v_dn))
```

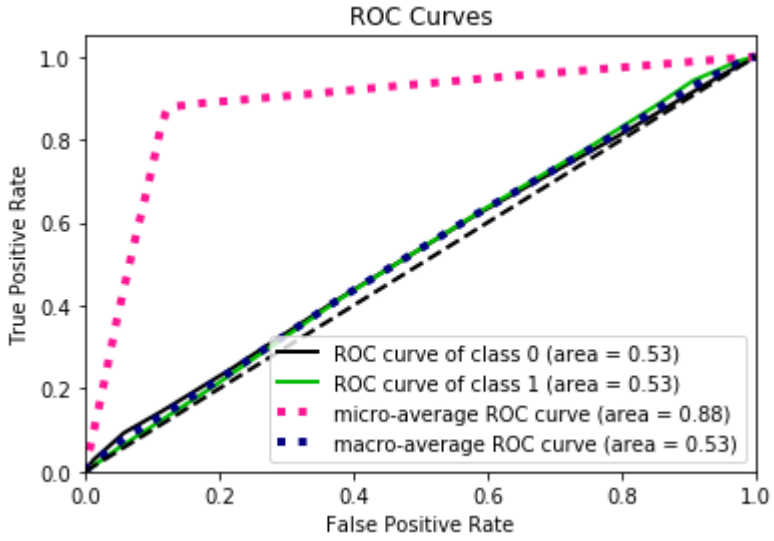
```
             precision    recall  f1-score   support

          0       0.11      0.05      0.07      1484
          1       0.88      0.94      0.91     10516

avg / total       0.78      0.83      0.80     12000
```

In [142]:
```
#Plotting ROC curve over Test Data
skplt.metrics.plot_roc_curve(y_test, pred_test_avgw2v_dn)
```

Out[142]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x16095ec84e0>
```



tfidf-W-w2v

In [143]:
```
fileObject = open("./final_to_file2.pkl",'rb') # we open the file for reading
final = pickle.load(fileObject) # load the object from the file
```

In [144]:
```
#w2v
# Train your own Word2Vec model using your own text corpus
i=0
list_of_sent=[]
for sent in final['CleanedText'].values:
    list_of_sent.append(sent.split())

print(type(list_of_sent))
print(final['CleanedText'].values[0])
print("**********************************************************************")
print(list_of_sent[0])
```

```
<class 'list'>
witti littl book make son laugh loud recit car drive along alway sing refrain h
es learn whale india droop love new word book introduc silli classic book will
bet son still abl recit memori colleg
**********************************************************************
['witti', 'littl', 'book', 'make', 'son', 'laugh', 'loud', 'recit', 'car', 'dri
ve', 'along', 'alway', 'sing', 'refrain', 'hes', 'learn', 'whale', 'india', 'dr
oop', 'love', 'new', 'word', 'book', 'introduc', 'silli', 'classic', 'book', 'w
ill', 'bet', 'son', 'still', 'abl', 'recit', 'memori', 'colleg']
```

In [145]:
```
w2v_model=Word2Vec(list_of_sent,min_count=5,size=50, workers=4)
w2v_words = list(w2v_model.wv.vocab)
```

In [146]:
```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
model = TfidfVectorizer()
tf_idf_matrix = model.fit_transform(final['CleanedText'].values)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(model.get_feature_names(), list(model.idf_)))
```

In [147]:
```
# TF-IDF weighted Word2Vec
tfidf_feat = model.get_feature_names() # tfidf words/col-names
# final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = t

tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in tl
row=0;
for sent in (list_of_sent): # for each review/sentence
    sent_vec = np.zeros(50) # as word vectors are of zero length
    weight_sum =0; # num of words with a valid vector in the sentence/review
    for word in sent: # for each word in a review/sentence
        if word in w2v_words:
            vec = w2v_model.wv[word]
#             tf_idf = tf_idf_matrix[row, tfidf_feat.index(word)]
            # to reduce the computation we are
            # dictionary[word] = idf value of word in whole courpus
            # sent.count(word) = tf valeus of word in this review
            tf_idf = dictionary[word]*(sent.count(word)/len(sent))
            sent_vec += (vec * tf_idf)
            weight_sum += tf_idf
    if weight_sum != 0:
        sent_vec /= weight_sum
    tfidf_sent_vectors.append(sent_vec)
    row += 1
```

In [148]:
```
print(len(tfidf_sent_vectors))
print(np.shape(tfidf_sent_vectors))
print(type(tfidf_sent_vectors))
```

```
60000
(60000, 50)
<class 'list'>
```

In [149]:
```
# create design matrix X and target vector y
X = np.array(sent_vectors[::]) # end index is exclusive
y = np.array(final['Score']) # showing you two ways of indexing a pandas df
```

In [150]:
```
X_train_nstd = X[0:38400:1]
X_cv_nstd = X[38400:48000:1]
X_test_nstd = X[48000:60000:1]

y_train_nstd = y[0:38400:1]
y_cv_nstd = y[38400:48000:1]
y_test_nstd =y[48000:60000:1]

print(X_train_nstd.shape)
print(X_cv_nstd.shape)
print(X_test_nstd.shape)
print(y_train_nstd.shape)
print(y_cv_nstd.shape)
print(y_test_nstd.shape)
```

```
(38400, 50)
(9600, 50)
(12000, 50)
(38400,)
(9600,)
(12000,)
```

In [151]:
```
# Column Standardization of the tfidf non-standard vector
std_scal = StandardScaler(with_mean=False)
std_scal.fit(X_train_nstd)
train_tfidfww2v = std_scal.transform(X_train_nstd)
cv_tfidfww2v = std_scal.transform(X_cv_nstd)
test_tfidfww2v = std_scal.transform(X_test_nstd)
```

In [178]:
```
roc_score_train_tfidfww2v = []
roc_score_cv_tfidfww2v = []
length = (train_tfidfww2v.shape)
length[0]
length1 = (cv_tfidfww2v.shape)
length1[0]
cv_scores_tfidfww2v = []
train_scores_tfidfww2v = []

for i in range(1,30,2):
    # instantiate learning model (k = 30)
    knn_tfidfww2v = KNeighborsClassifier(n_neighbors=i,algorithm='brute')

    # fitting the model on crossvalidation train
    knn_tfidfww2v.fit(train_tfidfww2v, y_train)

    #ROC score of Train Data
    train_prob_tfidfww2v = []
    for m in range(0,length[0],1000):
        train_prob_tfidfww2v.extend(knn_tfidfww2v.predict_proba(train_tfidfww2v[m

    train_prob2 = np.asarray(train_prob_tfidfww2v)
    train_prob3 = train_prob2[:,1]
    scores_train_tfidfww2v = roc_auc_score(y_train,train_prob3)
    roc_score_train_tfidfww2v.append(scores_train_tfidfww2v)

    cv_prob_tfidfww2v = []
    for n in range(0,length1[0],1000):
        cv_prob_tfidfww2v.extend(knn_tfidfww2v.predict_proba(cv_tfidfww2v[n:n+100

    cv_prob2 = np.asarray(cv_prob_tfidfww2v)
    cv_prob3 = cv_prob2[:,1]
    scores_cv_tfidfww2v = roc_auc_score(y_cv,cv_prob3)
    roc_score_cv_tfidfww2v.append(scores_cv_tfidfww2v)

    print("For Hyperparameter value of K = ",i)
    print("AUC Score on Train Data: ",roc_score_train_tfidfww2v[-1])
    print("AUC Score on CV Data: ",roc_score_cv_tfidfww2v[-1])
    print("**************")

# open the file for writing an array to fileto be save on disk
fileObject = open("./train_scores_tfidfww2v_to_file.pkl",'wb')
pickle.dump(roc_score_train_tfidfww2v,fileObject)   # this writes the object a to
fileObject.close() # here we close the fileObject

# open the file for writing an array to fileto be save on disk
fileObject = open("./cv_scores_tfidfww2v_to_file.pkl",'wb')
pickle.dump(roc_score_cv_tfidfww2v,fileObject)   # this writes the object a to th
fileObject.close() # here we close the fileObject
```

```
For Hyperparameter value of K =  1
AUC Score on Train Data:  1.0
AUC Score on CV Data:  0.6290918682733605
**************
For Hyperparameter value of K =  3
AUC Score on Train Data:  0.9544664526976484
AUC Score on CV Data:  0.7285839680046462
```

```
**************
For Hyperparameter value of K =  5
AUC Score on Train Data:  0.932633388113437
AUC Score on CV Data:  0.7635582887782505
**************
For Hyperparameter value of K =  7
AUC Score on Train Data:  0.9191737529619769
AUC Score on CV Data:  0.7840140109538016
**************
For Hyperparameter value of K =  9
AUC Score on Train Data:  0.9089419422235436
AUC Score on CV Data:  0.7943477067739765
**************
For Hyperparameter value of K =  11
AUC Score on Train Data:  0.902651538737849
AUC Score on CV Data:  0.8009534759351459
**************
For Hyperparameter value of K =  13
AUC Score on Train Data:  0.8965433801997478
AUC Score on CV Data:  0.8054173225563753
**************
For Hyperparameter value of K =  15
AUC Score on Train Data:  0.8924109739929174
AUC Score on CV Data:  0.8152335804744206
**************
For Hyperparameter value of K =  17
AUC Score on Train Data:  0.8883480375615025
AUC Score on CV Data:  0.8196566579706726
**************
For Hyperparameter value of K =  19
AUC Score on Train Data:  0.8853859376488077
AUC Score on CV Data:  0.8223847298231153
**************
For Hyperparameter value of K =  21
AUC Score on Train Data:  0.8822600368068264
AUC Score on CV Data:  0.8237529970096964
**************
For Hyperparameter value of K =  23
AUC Score on Train Data:  0.8805502177252726
AUC Score on CV Data:  0.8249434980377597
**************
For Hyperparameter value of K =  25
AUC Score on Train Data:  0.8782864417455782
AUC Score on CV Data:  0.8266995509222338
**************
For Hyperparameter value of K =  27
AUC Score on Train Data:  0.8767303127158053
AUC Score on CV Data:  0.8280965055218213
**************
For Hyperparameter value of K =  29
AUC Score on Train Data:  0.8743068030529206
AUC Score on CV Data:  0.829483294451865
**************
```

In [152]:
```
fileObject = open("./train_scores_tfidfww2v_to_file.pkl",'rb') # we open the file
train_scores_tfidfww2v = pickle.load(fileObject) # load the object from the file

fileObject = open("./cv_scores_tfidfww2v_to_file.pkl",'rb') # we open the file f
cv_scores_tfidfww2v = pickle.load(fileObject) # load the object from the file
```

In [153]:
```
# creating odd list of K for KNN
myList = list(range(0,30))
neighbors = list(filter(lambda x: x % 2 != 0, myList))
neighbors
```

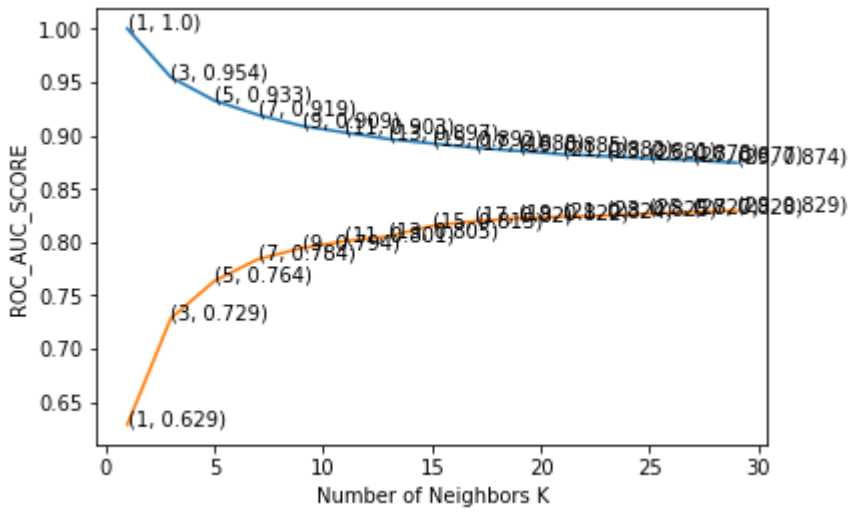
Out[153]:
```
[1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29]
```

In [154]:
```
plt.plot(neighbors, train_scores_tfidfww2v)
plt.plot(neighbors, cv_scores_tfidfww2v)

for xy in zip(neighbors, np.round(train_scores_tfidfww2v,3)):
    plt.annotate('(%s, %s)' % xy, xy=xy, textcoords='data')
for xy in zip(neighbors, np.round(cv_scores_tfidfww2v,3)):
    plt.annotate('(%s, %s)' % xy, xy=xy, textcoords='data')

plt.xlabel('Number of Neighbors K')
plt.ylabel('ROC_AUC_SCORE')

plt.show()
```



In [155]:
```
#Training KNN for best hyperparameter, K=29
knn_tfidfww2v = KNeighborsClassifier(29,algorithm='brute')
knn_tfidfww2v.fit(train_tfidfww2v,y_train)
#pred = knn.predict(test_bow)
```

Out[155]:
```
KNeighborsClassifier(algorithm='brute', leaf_size=30, metric='minkowski',
           metric_params=None, n_jobs=1, n_neighbors=29, p=2,
           weights='uniform')
```

In [170]:
```
#finding roc_auc_score on test data
roc_score_test_tfidfww2v = []
length3 = (test_tfidfww2v.shape)
pred_test_tfidfww2v = []
for i in range(0,length3[0],1000):
    pred_test_tfidfww2v.extend(knn_tfidfww2v.predict_proba(test_tfidfww2v[i:i+10(

test_prob2 = np.asarray(pred_test_tfidfww2v)
test_prob3 = test_prob2[:,1]
scores_test_tfidfww2v = roc_auc_score(y_test,test_prob3)
roc_score_test_tfidfww2v.append(scores_test_tfidfww2v)

#second method
fpr, tpr, thresholds = roc_curve(y_test, test_prob3)
roc_auc_tfidfww2v = auc(fpr, tpr,reorder='deprecated')
```

In [171]:
```
print(roc_score_test_tfidfww2v)
print(roc_auc_tfidfww2v)
```

```
[0.8013060447486515]
0.8013060447486515
```

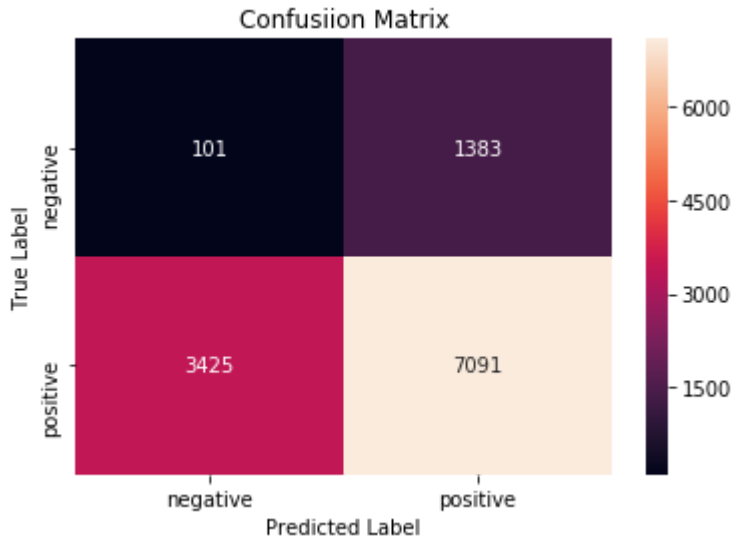
In [172]:
```
#defining own threshhold for prediction over probability values
def pred(y):
    y_pred = []
    for i in y:
        if i.all()>=0.5:
            y_pred.append(1)
        else:
            y_pred.append(0)
    return y_pred

y_pred_tfidfww2v  = pred(pred_test_tfidfww2v)
```

In [160]:
```
# Confusion Matrix on Test Data
#y_pred_tfidfww2v = np.argmax(pred_test_tfidfww2v, axis=1)
cm_tfidfww2v = confusion_matrix(y_test, pred_test_tfidfww2v)
cm_tfidfww2v
```

Out[160]:
```
array([[ 101, 1383],
       [3425, 7091]], dtype=int64)
```

In [161]:
```
# plot confusion matrix to describe the performance of classifier.
import seaborn as sns
class_label = ["negative", "positive"]
df_cm = pd.DataFrame(cm_tfidfww2v, index = class_label, columns = class_label)
sns.heatmap(df_cm, annot = True, fmt = "d")
plt.title("Confusiion Matrix")
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.show()
```



In [173]:
```
# To show main classification report
from sklearn.metrics import classification_report
print(classification_report(y_test, y_pred_tfidfww2v))
```

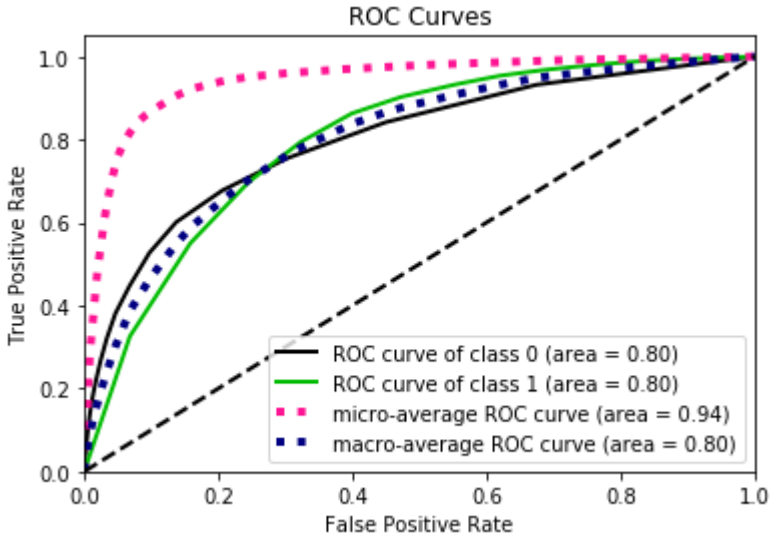
```
             precision    recall  f1-score   support

          0       0.03      0.07      0.04      1484
          1       0.84      0.67      0.75     10516

avg / total       0.74      0.60      0.66     12000
```

In [174]:
```
#Plotting ROC curve over Test Data
skplt.metrics.plot_roc_curve(y_test, pred_test_tfidfww2v)
```

Out[174]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x160d7cfeeb8>
```



tfidf-W-w2v KD-Tree

In [175]:
```
svd = TruncatedSVD()
train_tfidfww2v_dn = svd.fit_transform(train_tfidfww2v)
cv_tfidfww2v_dn = svd.transform(cv_tfidfww2v)
test_tfidfww2v_dn = svd.transform(test_tfidfww2v)
#X_tr_input = X_tr_input1
#x_cv_input = x_cv_input1
```

In [190]:
```
roc_score_train_tfidfww2v_dn = []
roc_score_cv_tfidfww2v_dn = []
length = (train_tfidfww2v_dn.shape)

length[0]
length1 = (cv_tfidfww2v_dn.shape)
length1[0]
cv_scores_tfidfww2v_dn = []
train_scores_tfidfww2v_dn = []

for i in range(1,30,2):
    # instantiate learning model (k = 30)
    knn_tfidfww2v_dn = KNeighborsClassifier(n_neighbors=i,algorithm='kd_tree')

    # fitting the model on crossvalidation train
    knn_tfidfww2v_dn.fit(train_tfidfww2v_dn, y_train)

    #ROC score of Train Data
    train_prob_tfidfww2v_dn = []
    for m in range(0,length[0],1000):
        train_prob_tfidfww2v_dn.extend(knn_tfidfww2v_dn.predict_proba(train_tfid

    train_prob2 = np.asarray(train_prob_tfidfww2v_dn)
    train_prob3 = train_prob2[:,1]
    scores_train_tfidfww2v_dn = roc_auc_score(y_train,train_prob3)
    roc_score_train_tfidfww2v_dn.append(scores_train_tfidfww2v_dn)

    cv_prob_tfidfww2v_dn = []
    for n in range(0,length1[0],1000):
        cv_prob_tfidfww2v_dn.extend(knn_tfidfww2v_dn.predict_proba(cv_tfidfww2v_

    cv_prob2 = np.asarray(cv_prob_tfidfww2v_dn)
    cv_prob3 = cv_prob2[:,1]
    scores_cv_tfidfww2v_dn = roc_auc_score(y_cv,cv_prob3)
    roc_score_cv_tfidfww2v_dn.append(scores_cv_tfidfww2v_dn)

    print("For Hyperparameter value of K = ",i)
    print("AUC Score on Train Data: ",roc_score_train_tfidfww2v_dn[-1])
    print("AUC Score on CV Data: ",roc_score_cv_tfidfww2v_dn[-1])
    print("**************")

# open the file for writing an array to fileto be save on disk
fileObject = open("./train_scores_tfidfww2v_dn_to_file.pkl",'wb')
pickle.dump(roc_score_train_tfidfww2v_dn,fileObject)   # this writes the object
fileObject.close() # here we close the fileObject

# open the file for writing an array to fileto be save on disk
fileObject = open("./cv_scores_tfidfww2v_dn_to_file.pkl",'wb')
pickle.dump(roc_score_cv_tfidfww2v_dn,fileObject)   # this writes the object a t
fileObject.close() # here we close the fileObject
```

```
For Hyperparameter value of K =  1
AUC Score on Train Data:  1.0
AUC Score on CV Data:  0.5007905803947984
**************
For Hyperparameter value of K =  3
AUC Score on Train Data:  0.9150161587849105
```

```
AUC Score on CV Data:  0.5049755896194782
**************
For Hyperparameter value of K =  5
AUC Score on Train Data:  0.860443396085576
AUC Score on CV Data:  0.5137076868641666
**************
For Hyperparameter value of K =  7
AUC Score on Train Data:  0.821447728032627
AUC Score on CV Data:  0.5103000054074975
**************
For Hyperparameter value of K =  9
AUC Score on Train Data:  0.7919104441432063
AUC Score on CV Data:  0.5177977455419015
**************
For Hyperparameter value of K =  11
AUC Score on Train Data:  0.7707894102460164
AUC Score on CV Data:  0.5201542648336811
**************
For Hyperparameter value of K =  13
AUC Score on Train Data:  0.7543325817165799
AUC Score on CV Data:  0.5291516807311277
**************
For Hyperparameter value of K =  15
AUC Score on Train Data:  0.739927897692815
AUC Score on CV Data:  0.5332197581443513
**************
For Hyperparameter value of K =  17
AUC Score on Train Data:  0.7303554420907622
AUC Score on CV Data:  0.5387462631850332
**************
For Hyperparameter value of K =  19
AUC Score on Train Data:  0.7208680350287665
AUC Score on CV Data:  0.5386308748521986
**************
For Hyperparameter value of K =  21
AUC Score on Train Data:  0.7129330466445586
AUC Score on CV Data:  0.5425683952633729
**************
For Hyperparameter value of K =  23
AUC Score on Train Data:  0.7064630008447415
AUC Score on CV Data:  0.5480899505277844
**************
For Hyperparameter value of K =  25
AUC Score on Train Data:  0.6998615170042771
AUC Score on CV Data:  0.5480153845433282
**************
For Hyperparameter value of K =  27
AUC Score on Train Data:  0.6953500825176222
AUC Score on CV Data:  0.547712915956844
**************
For Hyperparameter value of K =  29
AUC Score on Train Data:  0.6911258972865078
AUC Score on CV Data:  0.5499844907010203
**************
```

In [176]:
```
fileObject = open("./train_scores_tfidfww2v_dn_to_file.pkl",'rb') # we open the f
train_scores_tfidfww2v_dn = pickle.load(fileObject) # load the object from the fi

fileObject = open("./cv_scores_tfidfww2v_dn_to_file.pkl",'rb') # we open the file
cv_scores_tfidfww2v_dn = pickle.load(fileObject) # load the object from the file
```

In [177]:
```
# creating odd list of K for KNN
myList = list(range(0,30))
neighbors = list(filter(lambda x: x % 2 != 0, myList))
neighbors
```

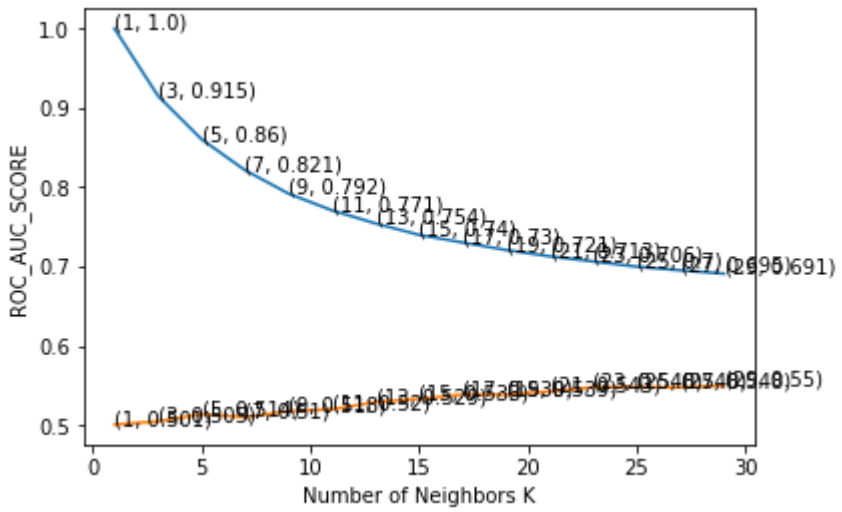
Out[177]:
```
[1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29]
```

In [178]:
```
plt.plot(neighbors, train_scores_tfidfww2v_dn)
plt.plot(neighbors, cv_scores_tfidfww2v_dn)

for xy in zip(neighbors, np.round(train_scores_tfidfww2v_dn,3)):
    plt.annotate('(%s, %s)' % xy, xy=xy, textcoords='data')
for xy in zip(neighbors, np.round(cv_scores_tfidfww2v_dn,3)):
    plt.annotate('(%s, %s)' % xy, xy=xy, textcoords='data')

plt.xlabel('Number of Neighbors K')
plt.ylabel('ROC_AUC_SCORE')

plt.show()
```



In [179]:
```
#Training KNN for best hyperparameter K=29
knn_tfidfww2v_dn = KNeighborsClassifier(29,algorithm='kd_tree')
knn_tfidfww2v_dn.fit(train_tfidfww2v_dn,y_train)
#pred = knn.predict(test_bow)
```

Out[179]:
```
KNeighborsClassifier(algorithm='kd_tree', leaf_size=30, metric='minkowski',
           metric_params=None, n_jobs=1, n_neighbors=29, p=2,
           weights='uniform')
```

In [180]:
```
#finding roc_auc_score on test data
roc_score_test_tfidfww2v_dn = []
length3 = (test_tfidfww2v_dn.shape)
pred_test_tfidfww2v_dn = []
for i in range(0,length3[0],1000):
    pred_test_tfidfww2v_dn.extend(knn_tfidfww2v_dn.predict_proba(test_tfidfww2v_

test_prob2 = np.asarray(pred_test_tfidfww2v_dn)
test_prob3 = test_prob2[:,1]
scores_test_tfidfww2v_dn = roc_auc_score(y_test,test_prob3)
roc_score_test_tfidfww2v_dn.append(scores_test_tfidfww2v_dn)

#second method
fpr, tpr, thresholds = roc_curve(y_test, test_prob3)
roc_auc_tfidfww2v_dn = auc(fpr, tpr,reorder='deprecated')
```

In [181]:
```
print(roc_score_test_tfidfww2v_dn)
print(roc_auc_tfidfww2v_dn)
```

```
[0.5401176323281991]
0.5401176323281991
```

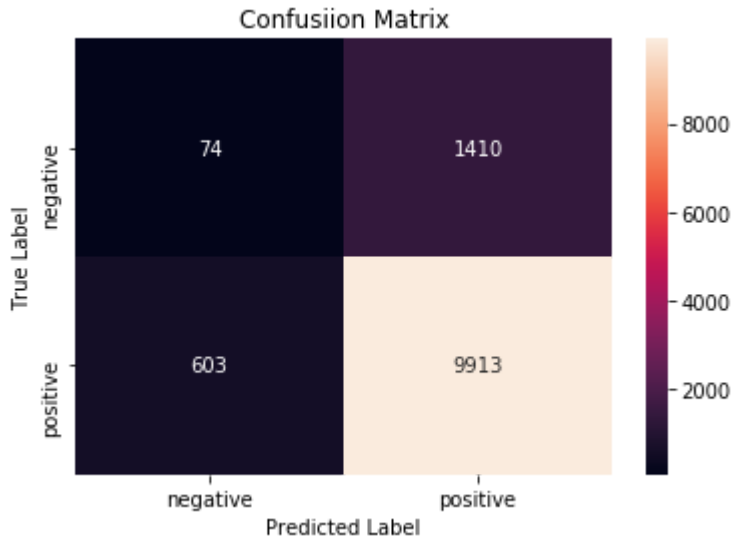
In [187]:
```
#defining own threshhold for prediction over probability values
def pred(y):
    y_pred = []
    for i in y:
        if i.all()>=0.5:
            y_pred.append(1)
        else:
            y_pred.append(0)
    return y_pred

y_pred_tfidfww2v_dn = pred(pred_test_tfidfww2v_dn)
```

In [188]:
```
# Confusion Matrix on Test Data
#y_pred_tfidfww2v_dn = np.argmax(pred_test_tfidfww2v_dn, axis=1)
cm_tfidfww2v_dn = confusion_matrix(y_test, y_pred_tfidfww2v_dn)
cm_tfidfww2v_dn
```

Out[188]:
```
array([[  74, 1410],
       [ 603, 9913]], dtype=int64)
```

In [189]:
```
# plot confusion matrix to describe the performance of classifier.
import seaborn as sns
class_label = ["negative", "positive"]
df_cm = pd.DataFrame(cm_tfidfww2v_dn, index = class_label, columns = class_label)
sns.heatmap(df_cm, annot = True, fmt = "d")
plt.title("Confusiion Matrix")
plt.xlabel("Predicted Label")
plt.ylabel("True Label")
plt.show()
```



In [192]:
```
# To show main classification report
from sklearn.metrics import classification_report
print(classification_report(y_test, y_pred_tfidfww2v_dn))
```

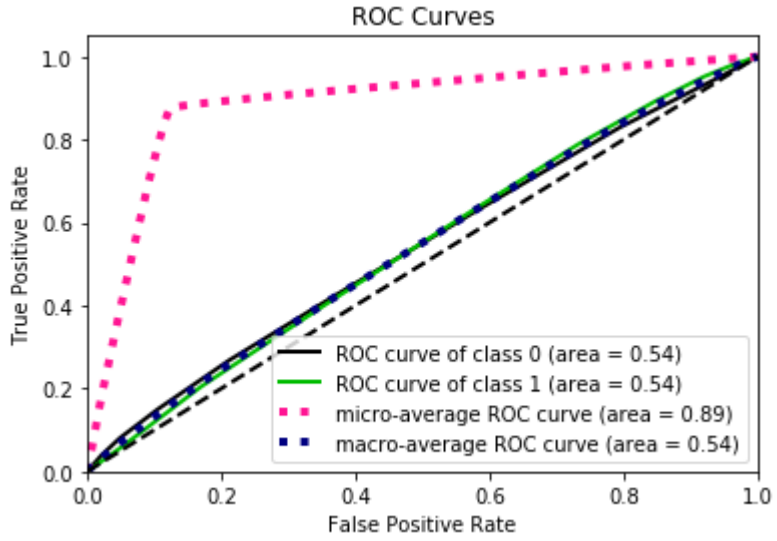
```
             precision    recall  f1-score   support

          0       0.11      0.05      0.07      1484
          1       0.88      0.94      0.91     10516

avg / total       0.78      0.83      0.80     12000
```

In [193]:
```
#Plotting ROC curve over Test Data
skplt.metrics.plot_roc_curve(y_test, pred_test_tfidfww2v_dn)
```

Out[193]: <matplotlib.axes._subplots.AxesSubplot at 0x160c8e83940>



In [197]:
```
x = PrettyTable()
x.field_names = ["Paramters/Models","BoW", "TF-IDF", "Avg w2v", "TFIDF-Avg-ww2v"

x.add_row(["Best Hyperparameter (Brute Force)", "29","19","29","29"])
x.add_row(["Best Hyperparameter (KD-Tree)","19" ,"25","29","29"])

x.add_row(["ROC_AUC_Score (Brute Force)", roc_score_test,roc_score_test_tfidf,ro
x.add_row(["ROC_AUC_Score (KD-Tree)", roc_score_test_dn,roc_score_test_tfidf_dn,

print(x)
```

```
+-----------------------------------+----------------------+------------------
---+----------------------+----------------------+
|          Paramters/Models         |         BoW          |        TF-IDF
|       Avg w2v        |    TFIDF-Avg-ww2v    |
+-----------------------------------+----------------------+------------------
---+----------------------+----------------------+
| Best Hyperparameter (Brute Force) |          29          |          19
|          29          |          29          |
|   Best Hyperparameter (KD-Tree)   |          19          |          25
|          29          |          29          |
|    ROC_AUC_Score (Brute Force)    | [0.7076795890026133] | [0.617988479113844
4] | [0.8041281787013806] | [0.8013060447486515] |
|      ROC_AUC_Score (KD-Tree)      | [0.5208303750208897] | [0.519762723263946
8] | [0.5260885671327173] | [0.5401176323281991] |
+-----------------------------------+----------------------+------------------
---+----------------------+----------------------+
```

In [ ]: