K- Nearest Neighbors on Amazon Food Reviews

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

# General Packages
import os
import sqlite3
import pandas as pd
import numpy as np
import string
import re
import nltk
import datetime
import time

# Plotting Packages
import matplotlib.pyplot as plt
import seaborn as sns

# Packages for Tfidf
from sklearn.feature_extraction.text import TfidfTransformer
from sklearn.feature_extraction.text import TfidfVectorizer

# Packages for BOW (Bag of words)
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.metrics import confusion_matrix
from sklearn import metrics
from sklearn.metrics import roc_curve, auc

# Packages for Text Preprocessing
from nltk.stem.porter import PorterStemmer
from nltk.corpus import stopwords
from nltk.stem.wordnet import WordNetLemmatizer

#Packages for Word2vec, Average Word2vec & Tf-Idf Weighted Word2Vec
from gensim.models import Word2Vec
from gensim.models import KeyedVectors
import pickle

#Packages for plotting Tsne plot
from sklearn.manifold import TSNE

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.metrics import classification_report, confusion_matrix
from sklearn.model_selection import TimeSeriesSplit
from prettytable import PrettyTable
from sklearn.metrics import recall_score
from sklearn.metrics import precision_score
from sklearn.metrics import f1_score
from sklearn.metrics import roc_curve
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import make_scorer, accuracy_score
from sklearn.decomposition import TruncatedSVD
```

In [2]:
```
# Formaing Output using pretty table
x = PrettyTable(["Model","Algorithm"," K ","TPR","TNR","Precision","Recall","F1-Score","FPR","FNR","PPV","NPV","Overall Accuracy (ACC)"])
from prettytable import MSWORD_FRIENDLY
x.set_style(MSWORD_FRIENDLY)
print(x)
```

```
| Model | Algorithm |  K  | TPR | TNR | Precision | Recall | F1-Score | FPR | FNR | PPV | NPV | Overall Accuracy (ACC) |
```

Preprocessing Stage: Cleansed Stop Words, Punctuations & Html tags

In [3]:
```
#Connecting the Sqlite file after the Preprocessing Stage
os.chdir('/Users/sujis/Downloads/AI/Sujit')
con = sqlite3.connect('final.sqlite')
final= pd.read_sql_query(""" SELECT * FROM Reviews """, con)
```

In [4]:
```
final.head(1)
```

Out[4]:

	index	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	Time	Summary	Text	CleanedText
0	138706	150524	0006641040	ACITT7DI6IDDL	shari zychinski	0	0	positive	939340800	EVERY book is educational	this witty little book makes my son laugh at l...	witti littl book make son laugh loud recit car...

In [5]:
```
final['Score'].value_counts()
```

Out[5]:
```
positive    307061
negative     57110
Name: Score, dtype: int64
```

Considering 50K data for KNN with 'Brute' Algorithm

In [209]:
```
# Taking 75K data points from the dataset
final_dataset=final.head(50000)
```

In [210]:
```
final_dataset['Score'].value_counts()
```

Out[210]:
```
positive    42540
negative     7460
Name: Score, dtype: int64
```

In [211]:
```
#Sorting the Dataframe with Date to apply Timebased Split
final_dataset=final_dataset.sort_values(by='Time',ascending=1)
```

In [212]:
```
# create design matrix X and target vector y
X = np.array(final_dataset.iloc[:, 0:12]) # end index is exclusive
Y = np.array(final_dataset['Score']) # showing you two ways of indexing a pandas df
```

In [213]:
```
#Time based split
tscv = TimeSeriesSplit(n_splits=5)
print(tscv)
```

```
TimeSeriesSplit(max_train_size=None, n_splits=5)
```

In [214]:
```
#Splitting the Dataset into Train set & Test set
for train_index, test_index in tscv.split(X):
   print("TRAIN:", train_index, "TEST:", test_index)
   X_tr, X_test = X[train_index], X[test_index]
   Y_tr, Y_test = Y[train_index], Y[test_index]
```

```
TRAIN: [    0     1     2 ... 8332 8333 8334] TEST: [ 8335  8336  8337 ... 16665 16666 16667]
TRAIN: [    0     1     2 ... 16665 16666 16667] TEST: [16668 16669 16670 ... 24998 24999 25000]
TRAIN: [    0     1     2 ... 24998 24999 25000] TEST: [25001 25002 25003 ... 33331 33332 33333]
TRAIN: [    0     1     2 ... 33331 33332 33333] TEST: [33334 33335 33336 ... 41664 41665 41666]
TRAIN: [    0     1     2 ... 41664 41665 41666] TEST: [41667 41668 41669 ... 49997 49998 49999]
```

In [215]:
```
# Splitting the Train dataset into Cross Validation & Train Datasets
for train_index, test_index in tscv.split(X_tr):
   print("TRAIN:", train_index, "TEST:", test_index)
   X_train, X_cv = X[train_index], X[test_index]
   Y_train, Y_cv = Y[train_index], Y[test_index]
```

```
TRAIN: [   0    1    2 ... 6944 6945 6946] TEST: [ 6947  6948  6949 ... 13888 13889 13890]
TRAIN: [    0     1     2 ... 13888 13889 13890] TEST: [13891 13892 13893 ... 20832 20833 20834]
TRAIN: [    0     1     2 ... 20832 20833 20834] TEST: [20835 20836 20837 ... 27776 27777 27778]
TRAIN: [    0     1     2 ... 27776 27777 27778] TEST: [27779 27780 27781 ... 34720 34721 34722]
TRAIN: [    0     1     2 ... 34720 34721 34722] TEST: [34723 34724 34725 ... 41664 41665 41666]
```

In [216]:
```
print(X_train.shape)
print(X_cv.shape)
print(X_test.shape)
print('-------------------')
print(Y_train.shape)
print(Y_cv.shape)
print(Y_test.shape)
```

```
(34723, 12)
(6944, 12)
(8333, 12)
-------------------
(34723,)
(6944,)
(8333,)
```

In [217]:
```
# Converting X_Train, X_cv & X_test data is  to Dataframe for the ease of use
X_train_data=pd.DataFrame(X_train, columns=['index', 'Id', 'ProductId', 'UserId', 'ProfileName',
       'HelpfulnessNumerator', 'HelpfulnessDenominator', 'Score', 'Time',
       'Summary', 'Text', 'CleanedText'])

X_cv_data=pd.DataFrame(X_cv, columns=['index', 'Id', 'ProductId', 'UserId', 'ProfileName',
       'HelpfulnessNumerator', 'HelpfulnessDenominator', 'Score', 'Time',
       'Summary', 'Text', 'CleanedText'])

X_test_data=pd.DataFrame(X_test, columns=['index', 'Id', 'ProductId', 'UserId', 'ProfileName',
       'HelpfulnessNumerator', 'HelpfulnessDenominator', 'Score', 'Time',
       'Summary', 'Text', 'CleanedText'])
```

Bag of Words

In [218]:
```
# create the transform
vectorizer = CountVectorizer()
# tokenize and build vocab
vectorizer.fit(X_train_data['CleanedText'].values)
# Bag of Words : Train Data Set
Train_X_vector = vectorizer.transform(X_train_data['CleanedText'].values)
# summarize encoded vector
print(Train_X_vector.shape)
```

```
(34723, 23935)
```

In [219]:
```
# Cross Validation Data Set
CV_X_vector = vectorizer.transform(X_cv_data['CleanedText'].values)
print(CV_X_vector.shape)
```

```
(6944, 23935)
```

In [220]:
```
#Test Data Set
Test_X_vector = vectorizer.transform(X_test_data['CleanedText'].values)
print(Test_X_vector.shape)
```

```
(8333, 23935)
```

In [221]:
```
print(Train_X_vector.shape)
print(CV_X_vector.shape)
print(Test_X_vector.shape)
print('-------------------')
print(Y_train.shape)
print(Y_cv.shape)
print(Y_test.shape)
```

```
(34723, 23935)
(6944, 23935)
(8333, 23935)
-------------------
(34723,)
(6944,)
(8333,)
```

In [222]:
```
start_time_code = time.time()
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_X_vector, Y_train)

    # predict the response on the crossvalidation train
    pred = knn.predict(CV_X_vector)

    # evaluate CV accuracy
    bag_acc = accuracy_score(Y_cv, pred, normalize=True) * float(100)
    print('\nCV accuracy for k = %d is %0.1f%%' % (i, bag_acc))
end_time_code = time.time()
print ("Running Time for code execution " + str(end_time_code - start_time_code) + " secs")
```

```
CV accuracy for k = 1 is 77.0%

CV accuracy for k = 3 is 81.8%

CV accuracy for k = 5 is 82.7%

CV accuracy for k = 7 is 82.7%

CV accuracy for k = 9 is 82.7%

CV accuracy for k = 11 is 82.7%

CV accuracy for k = 13 is 82.7%

CV accuracy for k = 15 is 82.7%

CV accuracy for k = 17 is 82.6%

CV accuracy for k = 19 is 82.5%

CV accuracy for k = 21 is 82.5%

CV accuracy for k = 23 is 82.5%

CV accuracy for k = 25 is 82.5%

CV accuracy for k = 27 is 82.5%

CV accuracy for k = 29 is 82.6%
Running Time for code execution 231.88899397850037 secs
```

In [223]:
```
knn = KNeighborsClassifier(15,algorithm="brute")
knn.fit(Train_X_vector,Y_train)
pred = knn.predict(Test_X_vector)
bag_test_acc = accuracy_score(Y_test, pred, normalize=True) * float(100)
print('\n****Test accuracy for k = 15 is %0.2f%%' % (bag_test_acc))
```

```
****Test accuracy for k = 15 is 81.70%
```

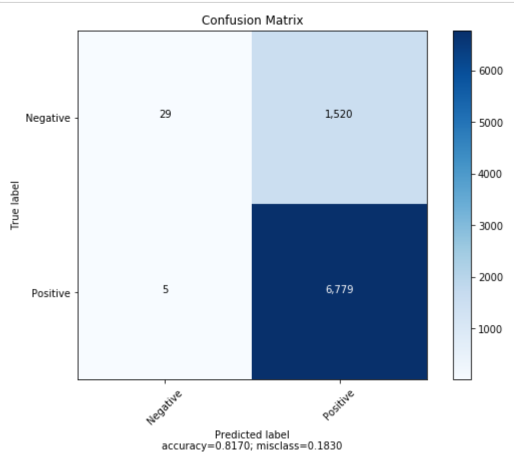
In [224]:
```
Conf_matrix=confusion_matrix(Y_test, pred)
```

In [225]:
```
Conf_matrix
```

Out[225]:
```
array([[  29, 1520],
       [   5, 6779]])
```

In [226]:
```
# Function for plotting Confusion Matrix
# Using this snipped of code copied from kaggle
import numpy as np


def plot_confusion_matrix(cm,
                          target_names,
                          title='Confusion matrix',
                          cmap=None,
                          normalize=True):

    import matplotlib.pyplot as plt
    import numpy as np
    import itertools

    accuracy = np.trace(cm) / float(np.sum(cm))
    misclass = 1 - accuracy

    if cmap is None:
        cmap = plt.get_cmap('Blues')

    plt.figure(figsize=(8, 6))
    plt.imshow(cm, interpolation='nearest', cmap=cmap)
    plt.title(title)
    plt.colorbar()

    if target_names is not None:
        tick_marks = np.arange(len(target_names))
        plt.xticks(tick_marks, target_names, rotation=45)
        plt.yticks(tick_marks, target_names)

    if normalize:
        cm = cm.astype('float') / cm.sum(axis=1)[:, np.newaxis]


    thresh = cm.max() / 1.5 if normalize else cm.max() / 2
    for i, j in itertools.product(range(cm.shape[0]), range(cm.shape[1])):
        if normalize:
            plt.text(j, i, "{:0.4f}".format(cm[i, j]),
                     horizontalalignment="center",
                     color="white" if cm[i, j] > thresh else "black")
        else:
            plt.text(j, i, "{:,}".format(cm[i, j]),
                     horizontalalignment="center",
                     color="white" if cm[i, j] > thresh else "black")


    plt.tight_layout()
    plt.ylabel('True label')
    plt.xlabel('Predicted label\naccuracy={:0.4f}; misclass={:0.4f}'.format(accuracy, misclass))
    plt.show()
```

In [227]:
```
plot_confusion_matrix(cm           = Conf_matrix,
                      normalize    = False,
                      target_names = ['Negative', 'Positive'],
                      title        = "Confusion Matrix")
```



In [228]:
```
Conf_matrix
```

Out[228]:
```
array([[  29, 1520],
       [   5, 6779]])
```

In [229]:
```
TN,FP,FN,TP = Conf_matrix.ravel()
#confusion_matrix(Y_test, pred)
```

In [230]:
```
# Sensitivity, hit rate, recall, or true positive rate
TPR ='{0:.2%}'.format( TP/(TP+FN))
# Specificity or true negative rate
TNR ='{0:.2%}'.format( TN/(TN+FP))
# Fall out or false positive rate
FPR ='{0:.2%}'.format( FP/(FP+TN))
# False negative rate
FNR ='{0:.2%}'.format( FN/(TP+FN))
# Precision or positive predictive value
PPV ='{0:.2%}'.format( TP/(TP+FP))
# Negative predictive value
NPV ='{0:.2%}'.format( TN/(TN+FN))
# Overall accuracy
ACC ='{0:.2%}'.format( (TP+TN)/(TP+FP+FN+TN))
```

In [231]:
```
Recall=recall_score(Y_test, pred, average='micro')
```

In [232]:
```
Precision=precision_score(Y_test, pred, average='micro')
```

In [233]:
```
F1_Score=f1_score(Y_test, pred, average='weighted')
```

In [234]:
```
pd.crosstab(Y_test, pred, rownames=['True'], colnames=['Predicted'], margins=True)
```

Out[234]:

Predicted	negative	positive	All
True			
negative	29	1520	1549
positive	5	6779	6784
All	34	8299	8333

In [235]:
```
x.add_row(["Bag of Words","Brute",15,TPR,TNR,'{0:.2f}'.format(Precision),'{0:.2f}'.format(Recall),'{0:.2f}'.format(F1_Score),FPR,FNR,PPV,NPV,ACC])
```

In [236]:
```
print(x)
```

```
|        Model          | Algorithm |  K |  TPR   |  TNR   | Precision | Recall | F1-Score |  FPR   |  FNR  |  PPV   |  NPV   | Overall Accuracy (ACC) |
|     Bag of Words      |  kd_tree  | 17 | 99.07% | 7.29%  |   0.82    |  0.82  |   0.76   | 92.71% | 0.93% | 82.33% | 64.15% |         81.94%         |
|       TF - IDF        |  Kd_tree  | 13 | 99.09% | 10.93% |   0.83    |  0.83  |   0.77   | 89.07% | 0.91% | 82.90% | 73.38% |         82.64%         |
|     Average W2V       |  Kd_tree  | 11 | 98.25% | 18.11% |   0.83    |  0.83  |   0.79   | 81.89% | 1.75% | 83.95% | 70.42% |         83.30%         |
|  TF - IDF Weighted W2V |  Kd_tree | 23 | 99.34% | 10.93% |   0.83    |  0.83  |   0.77   | 89.07% | 0.66% | 82.94% | 79.07% |         82.84%         |
|     Bag of Words      |   Brute   | 15 | 99.93% | 1.87%  |   0.82    |  0.82  |   0.74   | 98.13% | 0.07% | 81.68% | 85.29% |         81.70%         |
```

In [237]:
```
print(classification_report(Y_test, pred))
```

```
             precision    recall  f1-score   support

   negative       0.85      0.02      0.04      1549
   positive       0.82      1.00      0.90      6784

avg / total       0.82      0.82      0.74      8333
```

TF - IDF

In [238]:
```
tf_transformer = TfidfVectorizer(ngram_range=(1,2))
TF_vector=tf_transformer.fit(X_train_data['CleanedText'].values)
TF_train_Vector = TF_vector.transform(X_train_data['CleanedText'].values)
TF_train_Vector.shape
```

Out[238]: (34723, 598035)

In [239]:
```
TF_cv_Vector = TF_vector.transform(X_cv_data['CleanedText'].values)
TF_cv_Vector.shape
```

Out[239]: (6944, 598035)

In [240]:
```
TF_test_Vector = TF_vector.transform(X_test_data['CleanedText'].values)
TF_test_Vector.shape
```

Out[240]: (8333, 598035)

In [241]:
```
print(TF_train_Vector.shape)
print(TF_cv_Vector.shape)
print(TF_test_Vector.shape)
print('-------------------')
print(Y_train.shape)
print(Y_cv.shape)
print(Y_test.shape)
```

```
(34723, 598035)
(6944, 598035)
(8333, 598035)
-------------------
(34723,)
(6944,)
(8333,)
```

In [242]:
```
start_time_code = time.time()
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(TF_train_Vector, Y_train)

    # predict the response on the crossvalidation train
    pred = knn.predict(TF_cv_Vector)

    # evaluate CV accuracy
    tf_acc = accuracy_score(Y_cv, pred, normalize=True) * float(100)
    print('\nCV accuracy for k = %d is %0.2f%%' % (i, tf_acc))
end_time_code = time.time()
print ("Running Time for code execution " + str(end_time_code - start_time_code) + " secs")
```

```
CV accuracy for k = 1 is 80.04%

CV accuracy for k = 3 is 83.19%

CV accuracy for k = 5 is 83.60%

CV accuracy for k = 7 is 83.81%

CV accuracy for k = 9 is 83.68%

CV accuracy for k = 11 is 83.80%

CV accuracy for k = 13 is 83.74%

CV accuracy for k = 15 is 83.60%

CV accuracy for k = 17 is 83.50%

CV accuracy for k = 19 is 83.40%

CV accuracy for k = 21 is 83.40%

CV accuracy for k = 23 is 83.35%

CV accuracy for k = 25 is 83.31%

CV accuracy for k = 27 is 83.35%

CV accuracy for k = 29 is 83.37%
Running Time for code execution 213.33067083358765 secs
```

In [243]:
```
knn = KNeighborsClassifier(11,algorithm="brute")
knn.fit(TF_train_Vector,Y_train)
pred = knn.predict(TF_test_Vector)
tf_test_acc = accuracy_score(Y_test, pred, normalize=True) * float(100)
print('\n****Test accuracy for k = 11 is %0.2f%%' % (tf_test_acc))
```

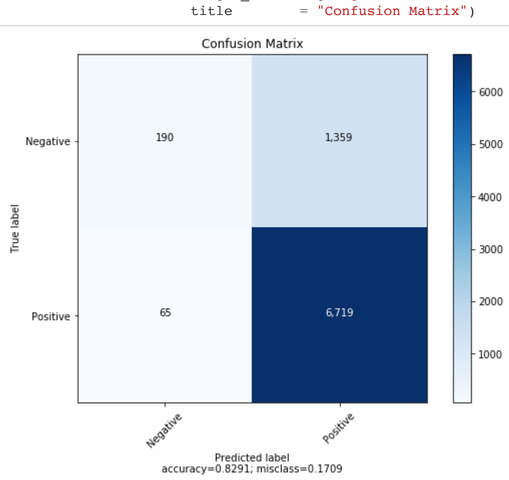
```
****Test accuracy for k = 11 is 82.91%
```

In [244]:
```
Conf_matrix=confusion_matrix(Y_test, pred)
```

In [245]:
```
Conf_matrix
```

Out[245]:
```
array([[ 190, 1359],
       [  65, 6719]])
```

In [246]:
```
plot_confusion_matrix(cm           = Conf_matrix,
                      normalize    = False,
                      target_names = ['Negative', 'Positive'],
                      title        = "Confusion Matrix")
```



In [247]:
```
TN,FP,FN,TP = Conf_matrix.ravel()
#confusion_matrix(Y_test, pred)
```

In [248]:
```
# Sensitivity, hit rate, recall, or true positive rate
TPR ='{0:.2%}'.format( TP/(TP+FN))
# Specificity or true negative rate
TNR ='{0:.2%}'.format( TN/(TN+FP))
# Fall out or false positive rate
FPR ='{0:.2%}'.format( FP/(FP+TN))
# False negative rate
FNR ='{0:.2%}'.format( FN/(TP+FN))
# Precision or positive predictive value
PPV ='{0:.2%}'.format( TP/(TP+FP))
# Negative predictive value
NPV ='{0:.2%}'.format( TN/(TN+FN))
# Overall accuracy
ACC ='{0:.2%}'.format( (TP+TN)/(TP+FP+FN+TN))
```

In [249]:
```
Recall=recall_score(Y_test, pred, average='micro')
```

In [250]:
```
Precision=precision_score(Y_test, pred, average='micro')
```

In [251]:
```
F1_Score=f1_score(Y_test, pred, average='weighted')
```

In [252]:
```
pd.crosstab(Y_test, pred, rownames=['True'], colnames=['Predicted'], margins=True)
```

Out[252]:

Predicted	negative	positive	All
True			
negative	190	1359	1549
positive	65	6719	6784
All	255	8078	8333

In [253]:
```
x.add_row(["TF - IDF","Brute",11,TPR,TNR,'{0:.2f}'.format(Precision),'{0:.2f}'.format(Recall),'{0:.2f}'.format(F1_Score),FPR,FNR,PPV,NPV,ACC])
```

In [254]:
```
print(classification_report(Y_test, pred))
```

```
             precision    recall  f1-score   support

   negative       0.75      0.12      0.21      1549
   positive       0.83      0.99      0.90      6784

avg / total       0.82      0.83      0.78      8333
```

In [255]:
```
print(x)
```

Model	Algorithm	K	TPR	TNR	Precision	Recall	F1-Score	FPR	FNR	PPV	NPV	Overall Accuracy (ACC)
Bag of Words	kd_tree	17	99.07%	7.29%	0.82	0.82	0.76	92.71%	0.93%	82.33%	64.15%	81.94%
TF - IDF	Kd_tree	13	99.09%	10.93%	0.83	0.83	0.77	89.07%	0.91%	82.90%	73.38%	82.64%
Average W2V	Kd_tree	11	98.25%	18.11%	0.83	0.83	0.79	81.89%	1.75%	83.95%	70.42%	83.30%
TF - IDF Weighted W2V	Kd_tree	23	99.34%	10.93%	0.83	0.83	0.77	89.07%	0.66%	82.94%	79.07%	82.84%
Bag of Words	Brute	15	99.93%	1.87%	0.82	0.82	0.74	98.13%	0.07%	81.68%	85.29%	81.70%
TF - IDF	Brute	11	99.04%	12.27%	0.83	0.83	0.78	87.73%	0.96%	83.18%	74.51%	82.91%

Average W2V

In [256]:
```
# Train your own Word2Vec model using your own text corpus for Training Dataset
i=0
list_of_sent=[]
for sent in X_train_data['CleanedText'].values:
    list_of_sent.append(sent.split())

# min_count = 5 considers only words that occured atleast 5 times
Trained_model=Word2Vec(list_of_sent,min_count=5,size=50, workers=4)

w2v_words = list(Trained_model.wv.vocab)
print("number of words that occured minimum 5 times ",len(w2v_words))
print("sample words ", w2v_words[0:50])
```

```
number of words that occured minimum 5 times  8321
sample words  ['littl', 'book', 'make', 'son', 'laugh', 'loud', 'car', 'drive', 'along', 'alway', 'sing', 'refrain', 'hes', 'learn', 'india', 'love', 'new', 'wo
rd', 'introduc', 'silli', 'classic', 'will', 'bet', 'still', 'abl', 'memori', 'colleg', 'rememb', 'see', 'show', 'air', 'televis', 'year', 'ago', 'child', 'sist
er', 'later', 'bought', 'day', 'thirti', 'someth', 'use', 'seri', 'song', 'student', 'teach', 'preschool', 'turn', 'whole', 'school']
```

In [257]:
```
# average Word2Vec
# compute average word2vec for each review.
start_time_code = time.time()
Trained_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 = Trained_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    Trained_vectors.append(sent_vec)
print(len(Trained_vectors))
end_time_code = time.time()
print ("Running Time for code execution " + str(end_time_code - start_time_code) + " secs")
```

```
34723
Running Time for code execution 62.595484018325806 secs
```

In [258]:
```
Train_X=Trained_vectors
```

In [260]:
```
# Train your own Word2Vec model using your own text corpus
i=0
list_of_sent_cv=[]
for sent in X_cv_data['CleanedText'].values:
    list_of_sent_cv.append(sent.split())
```

In [261]:
```
# average Word2Vec
# compute average word2vec for each review.
start_time_code = time.time()
Cv_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sent in list_of_sent_cv: # 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 = Trained_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    Cv_vectors.append(sent_vec)
print(len(Cv_vectors))
end_time_code = time.time()
print ("Running Time for code execution " + str(end_time_code - start_time_code) + " secs")
```

```
6944
Running Time for code execution 11.396867990493774 secs
```

In [262]:
```
CV_X=Cv_vectors
```

In [264]:
```
# Train your own Word2Vec model using your own text corpus
i=0
list_of_sent_test=[]
for sent in X_test_data['CleanedText'].values:
    list_of_sent_test.append(sent.split())
```

In [265]:
```
# average Word2Vec
# compute average word2vec for each review.
start_time_code = time.time()
test_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sent in list_of_sent_test: # 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 = Trained_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    test_vectors.append(sent_vec)
print(len(test_vectors))
end_time_code = time.time()
print ("Running Time for code execution " + str(end_time_code - start_time_code) + " secs")
```

```
8333
Running Time for code execution 14.642790079116821 secs
```

In [266]:
```
Test_X=test_vectors
```

In [267]:
```
print (len(Train_X))
print(len(CV_X))
print(len(Test_X))
print('-----------------')
print (Y_train.shape)
print(Y_cv.shape)
print(Y_test.shape)
```

```
34723
6944
8333
-----------------
(34723,)
(6944,)
(8333,)
```

In [268]:
```
start_time_code = time.time()
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_X, Y_train)

    # predict the response on the crossvalidation train
    pred = knn.predict(CV_X)

    # evaluate CV accuracy
    train_acc = accuracy_score(Y_cv, pred, normalize=True) * float(100)
    print('\nCV accuracy for k = %d is %0.2f%%' % (i, train_acc))
end_time_code = time.time()
print ("Running Time for code execution " + str(end_time_code - start_time_code) + " secs")
```

```
CV accuracy for k = 1 is 80.17%

CV accuracy for k = 3 is 83.45%

CV accuracy for k = 5 is 84.12%

CV accuracy for k = 7 is 84.48%

CV accuracy for k = 9 is 84.59%

CV accuracy for k = 11 is 84.53%

CV accuracy for k = 13 is 84.48%

CV accuracy for k = 15 is 84.48%

CV accuracy for k = 17 is 84.56%

CV accuracy for k = 19 is 84.52%

CV accuracy for k = 21 is 84.45%

CV accuracy for k = 23 is 84.36%

CV accuracy for k = 25 is 84.38%

CV accuracy for k = 27 is 84.25%

CV accuracy for k = 29 is 84.17%
Running Time for code execution 105.32548975944519 secs
```

In [269]:
```
# Since the train accuracy for k is the same from k=3 to k=29. so the smallest k at maximum accuracy is the best i.e. k=3
knn = KNeighborsClassifier(17,algorithm="brute")
knn.fit(Train_X,Y_train)
pred = knn.predict(Test_X)
test_acc = accuracy_score(Y_test, pred, normalize=True) * float(100)
print('\n****Test accuracy for k = 17 is %0.2f%%' % (test_acc))
```

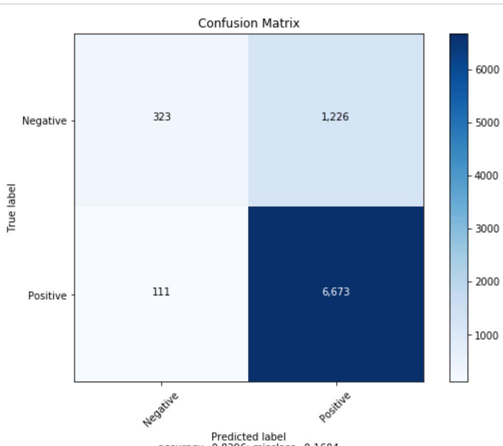
```
****Test accuracy for k = 17 is 83.96%
```

In [270]:
```
Conf_matrix=confusion_matrix(Y_test, pred)
```

In [271]:
```
Conf_matrix
```

Out[271]:
```
array([[ 323, 1226],
       [ 111, 6673]])
```

In [272]:
```
plot_confusion_matrix(cm           = Conf_matrix,
                      normalize    = False,
                      target_names = ['Negative', 'Positive'],
                      title        = "Confusion Matrix")
```



In [273]:
```
TN,FP,FN,TP = Conf_matrix.ravel()
#confusion_matrix(Y_test, pred)
```

In [274]:
```
# Sensitivity, hit rate, recall, or true positive rate
TPR ='{0:.2%}'.format( TP/(TP+FN))
# Specificity or true negative rate
TNR ='{0:.2%}'.format( TN/(TN+FP))
# Fall out or false positive rate
FPR ='{0:.2%}'.format( FP/(FP+TN))
# False negative rate
FNR ='{0:.2%}'.format( FN/(TP+FN))
# Precision or positive predictive value
PPV ='{0:.2%}'.format( TP/(TP+FP))
# Negative predictive value
NPV ='{0:.2%}'.format( TN/(TN+FN))
# Overall accuracy
ACC ='{0:.2%}'.format( (TP+TN)/(TP+FP+FN+TN))
```

In [275]:
```
Recall=recall_score(Y_test, pred, average='micro')
```

In [276]:
```
Precision=precision_score(Y_test, pred, average='micro')
```

In [277]:
```
F1_Score=f1_score(Y_test, pred, average='weighted')
```

In [278]:
```
pd.crosstab(Y_test, pred, rownames=['True'], colnames=['Predicted'], margins=True)
```

Out[278]:

Predicted	negative	positive	All
True			
negative	323	1226	1549
positive	111	6673	6784
All	434	7899	8333

In [279]:
```
x.add_row([" Average W2V","Brute",17,TPR,TNR,'{0:.2f}'.format(Precision),'{0:.2f}'.format(Recall),'{0:.2f}'.format(F1_Score),FPR,FNR,PPV,NPV,ACC])
```

In [280]:
```
print(classification_report(Y_test, pred))
```

```
             precision    recall  f1-score   support

   negative       0.74      0.21      0.33      1549
   positive       0.84      0.98      0.91      6784

avg / total       0.83      0.84      0.80      8333
```

In [281]:
```
print(x)
```

Model	Algorithm	K	TPR	TNR	Precision	Recall	F1-Score	FPR	FNR	PPV	NPV	Overall Accuracy (ACC)
Bag of Words	kd_tree	17	99.07%	7.29%	0.82	0.82	0.76	92.71%	0.93%	82.33%	64.15%	81.94%
TF - IDF	Kd_tree	13	99.09%	10.93%	0.83	0.83	0.77	89.07%	0.91%	82.90%	73.38%	82.64%
Average W2V	Kd_tree	11	98.25%	18.11%	0.83	0.83	0.79	81.89%	1.75%	83.95%	70.42%	83.30%
TF - IDF Weighted W2V	Kd_tree	23	99.34%	10.93%	0.83	0.83	0.77	89.07%	0.66%	82.94%	79.07%	82.84%
Bag of Words	Brute	15	99.93%	1.87%	0.82	0.82	0.74	98.13%	0.07%	81.68%	85.29%	81.70%
TF - IDF	Brute	11	99.04%	12.27%	0.83	0.83	0.78	87.73%	0.96%	83.18%	74.51%	82.91%
Average W2V	Brute	17	98.36%	20.85%	0.84	0.84	0.80	79.15%	1.64%	84.48%	74.42%	83.96%

TF-IDF weighted Word2Vec

In [26]:
```
# TF-IDF weighted Word2Vec
tfidf_feat = TF_vector.get_feature_names() # tfidf words/col-names
```

In [87]:
```
# final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = tfidf
start_time_code = time.time()
tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in this list
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 = Trained_model.wv[word]
            # obtain the tf_idfidf of a word in a sentence/review
            tf_idf = TF_train_Vector[row, tfidf_feat.index(word)]
            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
end_time_code = time.time()
print ("Running Time for code execution " + str(end_time_code - start_time_code) + " secs")
```

```
Running Time for code execution 28771.18012213707 secs
```

In [88]:
```
Train_X=tfidf_sent_vectors
```

In [89]:
```
df = pd.DataFrame.from_records(Train_X)
df.to_csv('TF-IDF_W2V_Train.csv',index=None)
```

In [282]:
```
Train_X = pd.read_csv("TF-IDF_W2V_Train.csv")
```

In [116]:
```
len(Train_X)
```

Out[116]: 34723

In [92]:
```
# final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = tfidf
start_time_code = time.time()
tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in this list
row=0;
for sent in list_of_sent_cv: # 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 = Trained_model.wv[word]
            # obtain the tf_idfidf of a word in a sentence/review
            tf_idf = TF_cv_Vector[row, tfidf_feat.index(word)]
            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
end_time_code = time.time()
print ("Running Time for code execution " + str(end_time_code - start_time_code) + " secs")
```

```
Running Time for code execution 5836.9589948654175 secs
```

In [93]:
```
CV_X=tfidf_sent_vectors
```

In [94]:
```
df = pd.DataFrame.from_records(CV_X)
df.to_csv('TF-IDF_W2V_CV.csv',index=None)
```

In [283]:
```
CV_X = pd.read_csv("TF-IDF_W2V_CV.csv")
```

In [27]:
```
# final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = tfidf
start_time_code = time.time()
tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in this list
row=0;
for sent in list_of_sent_test: # 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 = Trained_model.wv[word]
            # obtain the tf_idfidf of a word in a sentence/review
            tf_idf = TF_test_Vector[row, tfidf_feat.index(word)]
            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
end_time_code = time.time()
print ("Running Time for code execution " + str(end_time_code - start_time_code) + " secs")
```

```
Running Time for code execution 7043.685368061066 secs
```

In [28]:
```
Test_X=tfidf_sent_vectors
```

In [29]:
```
df = pd.DataFrame.from_records(Test_X)
df.to_csv('TF-IDF_W2V_test.csv',index=None)
```

In [284]:
```
Test_X = pd.read_csv("TF-IDF_W2V_test.csv")
```

In [285]:
```
start_time_code = time.time()
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_X, Y_train)

    # predict the response on the crossvalidation train
    pred = knn.predict(CV_X)

    # evaluate CV accuracy
    train_acc = accuracy_score(Y_cv, pred, normalize=True) * float(100)
    print('\nCV accuracy for k = %d is %0.2f%%' % (i, train_acc))
end_time_code = time.time()
print ("Running Time for code execution " + str(end_time_code - start_time_code) + " secs")
```

```
CV accuracy for k = 1 is 80.11%

CV accuracy for k = 3 is 82.75%

CV accuracy for k = 5 is 83.55%

CV accuracy for k = 7 is 83.73%

CV accuracy for k = 9 is 83.94%

CV accuracy for k = 11 is 83.71%

CV accuracy for k = 13 is 83.67%

CV accuracy for k = 15 is 83.50%

CV accuracy for k = 17 is 83.53%

CV accuracy for k = 19 is 83.44%

CV accuracy for k = 21 is 83.48%

CV accuracy for k = 23 is 83.38%

CV accuracy for k = 25 is 83.45%

CV accuracy for k = 27 is 83.38%

CV accuracy for k = 29 is 83.41%
Running Time for code execution 100.78603434562683 secs
```

In [286]:
```
# Since the train accuracy for k is the same from k=3 to k=29. so the smallest k at maximum accuracy is the best i.e. k=3
knn = KNeighborsClassifier(9,algorithm="brute")
knn.fit(Train_X,Y_train)
pred = knn.predict(Test_X)
test_acc = accuracy_score(Y_test, pred, normalize=True) * float(100)
print('\n****Test accuracy for k = 9 is %0.2f%%' % (test_acc))
```

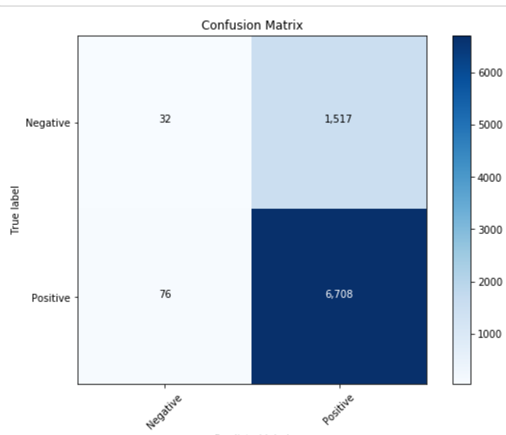
```
****Test accuracy for k = 9 is 80.88%
```

In [287]:
```
Conf_matrix=confusion_matrix(Y_test, pred)
```

In [288]:
```
Conf_matrix
```

Out[288]:
```
array([[  32, 1517],
       [  76, 6708]])
```

In [289]:
```
plot_confusion_matrix(cm           = Conf_matrix,
                      normalize    = False,
                      target_names = ['Negative', 'Positive'],
                      title        = "Confusion Matrix")
```



In [290]:
```
TN,FP,FN,TP = Conf_matrix.ravel()
#confusion_matrix(Y_test, pred)
```

In [291]:
```
# Sensitivity, hit rate, recall, or true positive rate
TPR ='{0:.2%}'.format( TP/(TP+FN))
# Specificity or true negative rate
TNR ='{0:.2%}'.format( TN/(TN+FP))
# Fall out or false positive rate
FPR ='{0:.2%}'.format( FP/(FP+TN))
# False negative rate
FNR ='{0:.2%}'.format( FN/(TP+FN))
# Precision or positive predictive value
PPV ='{0:.2%}'.format( TP/(TP+FP))
# Negative predictive value
NPV ='{0:.2%}'.format( TN/(TN+FN))
# Overall accuracy
ACC ='{0:.2%}'.format( (TP+TN)/(TP+FP+FN+TN))
```

In [292]:
```
Recall=recall_score(Y_test, pred, average='micro')
```

In [293]:
```
Precision=precision_score(Y_test, pred, average='micro')
```

In [294]:
```
F1_Score=f1_score(Y_test, pred, average='weighted')
```

In [295]:
```
pd.crosstab(Y_test, pred, rownames=['True'], colnames=['Predicted'], margins=True)
```

Out[295]:

Predicted	negative	positive	All
True			
negative	32	1517	1549
positive	76	6708	6784
All	108	8225	8333

In [296]:
```
x.add_row([" TF-IDF Weighted W2V ","Brute",17,TPR,TNR,'{0:.2f}'.format(Precision),'{0:.2f}'.format(Recall),'{0:.2f}'.format(F1_Score),FPR,FNR,PPV,NPV,ACC])
```

In [297]:
```
print(classification_report(Y_test, pred))
```

```
             precision    recall  f1-score   support

   negative       0.30      0.02      0.04      1549
   positive       0.82      0.99      0.89      6784

avg / total       0.72      0.81      0.73      8333
```

In [298]:
```
print(x)
```

```
|        Model         | Algorithm | K  |  TPR   |  TNR   | Precision | Recall | F1-Score |  FPR   |  FNR  |  PPV   |  NPV   | Overall Accuracy (ACC) |
|     Bag of Words     |  kd_tree  | 17 | 99.07% | 7.29%  |    0.82   |  0.82  |   0.76   | 92.71% | 0.93% | 82.33% | 64.15% |         81.94%         |
|       TF - IDF       |  Kd_tree  | 13 | 99.09% | 10.93% |    0.83   |  0.83  |   0.77   | 89.07% | 0.91% | 82.90% | 73.38% |         82.64%         |
|     Average W2V      |  Kd_tree  | 11 | 98.25% | 18.11% |    0.83   |  0.83  |   0.79   | 81.89% | 1.75% | 83.95% | 70.42% |         83.30%         |
|  TF - IDF Weighted W2V |  Kd_tree  | 23 | 99.34% | 10.93% |    0.83   |  0.83  |   0.77   | 89.07% | 0.66% | 82.94% | 79.07% |         82.84%         |
|     Bag of Words     |   Brute   | 15 | 99.93% | 1.87%  |    0.82   |  0.82  |   0.74   | 98.13% | 0.07% | 81.68% | 85.29% |         81.70%         |
|       TF - IDF       |   Brute   | 11 | 99.04% | 12.27% |    0.83   |  0.83  |   0.78   | 87.73% | 0.96% | 83.18% | 74.51% |         82.91%         |
|     Average W2V      |   Brute   | 17 | 98.36% | 20.85% |    0.84   |  0.84  |   0.80   | 79.15% | 1.64% | 84.48% | 74.42% |         83.96%         |
|  TF-IDF Weighted W2V |   Brute   | 17 | 98.88% | 2.07%  |    0.81   |  0.81  |   0.73   | 97.93% | 1.12% | 81.56% | 29.63% |         80.88%         |
```

Considering 30K data for KNN with 'kd_tree' Algorithm

In [6]:
```
# Taking 75K data points from the dataset
final_dataset=final.head(30000)
```

In [7]:
```
final_dataset['Score'].value_counts()
```

Out[7]:
```
positive    25494
negative     4506
Name: Score, dtype: int64
```

In [8]:
```
#Sorting the Dataframe with Date to apply Timebased Split
final_dataset=final_dataset.sort_values(by='Time',ascending=1)
```

In [9]:
```
# create design matrix X and target vector y
X = np.array(final_dataset.iloc[:, 0:12]) # end index is exclusive
Y = np.array(final_dataset['Score']) # showing you two ways of indexing a pandas df
```

In [10]:
```
#Time based split
tscv = TimeSeriesSplit(n_splits=5)
print(tscv)
```

```
TimeSeriesSplit(max_train_size=None, n_splits=5)
```

In [11]:
```
#Splitting the Dataset into Train set & Test set
for train_index, test_index in tscv.split(X):
   print("TRAIN:", train_index, "TEST:", test_index)
   X_tr, X_test = X[train_index], X[test_index]
   Y_tr, Y_test = Y[train_index], Y[test_index]
```

```
TRAIN: [    0     1     2 ... 4997 4998 4999] TEST: [5000 5001 5002 ... 9997 9998 9999]
TRAIN: [    0     1     2 ... 9997 9998 9999] TEST: [10000 10001 10002 ... 14997 14998 14999]
TRAIN: [    0     1     2 ... 14997 14998 14999] TEST: [15000 15001 15002 ... 19997 19998 19999]
TRAIN: [    0     1     2 ... 19997 19998 19999] TEST: [20000 20001 20002 ... 24997 24998 24999]
TRAIN: [    0     1     2 ... 24997 24998 24999] TEST: [25000 25001 25002 ... 29997 29998 29999]
```

In [12]:
```
# Splitting the Train dataset into Cross Validation & Train Datasets
for train_index, test_index in tscv.split(X_tr):
   print("TRAIN:", train_index, "TEST:", test_index)
   X_train, X_cv = X[train_index], X[test_index]
   Y_train, Y_cv = Y[train_index], Y[test_index]
```

```
TRAIN: [    0     1     2 ... 4167 4168 4169] TEST: [4170 4171 4172 ... 8333 8334 8335]
TRAIN: [    0     1     2 ... 8333 8334 8335] TEST: [ 8336  8337  8338 ... 12499 12500 12501]
TRAIN: [    0     1     2 ... 12499 12500 12501] TEST: [12502 12503 12504 ... 16665 16666 16667]
TRAIN: [    0     1     2 ... 16665 16666 16667] TEST: [16668 16669 16670 ... 20831 20832 20833]
TRAIN: [    0     1     2 ... 20831 20832 20833] TEST: [20834 20835 20836 ... 24997 24998 24999]
```

In [13]:
```
print(X_train.shape)
print(X_cv.shape)
print(X_test.shape)
print('-------------------')
print(Y_train.shape)
print(Y_cv.shape)
print(Y_test.shape)
```

```
(20834, 12)
(4166, 12)
(5000, 12)
-------------------
(20834,)
(4166,)
(5000,)
```

In [14]:
```
# Converting X_Train, X_cv & X_test data is  to Dataframe for the ease of use
X_train_data=pd.DataFrame(X_train, columns=['index', 'Id', 'ProductId', 'UserId', 'ProfileName',
       'HelpfulnessNumerator', 'HelpfulnessDenominator', 'Score', 'Time',
       'Summary', 'Text', 'CleanedText'])

X_cv_data=pd.DataFrame(X_cv, columns=['index', 'Id', 'ProductId', 'UserId', 'ProfileName',
       'HelpfulnessNumerator', 'HelpfulnessDenominator', 'Score', 'Time',
       'Summary', 'Text', 'CleanedText'])

X_test_data=pd.DataFrame(X_test, columns=['index', 'Id', 'ProductId', 'UserId', 'ProfileName',
       'HelpfulnessNumerator', 'HelpfulnessDenominator', 'Score', 'Time',
       'Summary', 'Text', 'CleanedText'])
```

Bag of Words

In [118]:
```
# create the transform
vectorizer = CountVectorizer()
# tokenize and build vocab
vectorizer.fit(X_train_data['CleanedText'].values)
# Bag of Words : Train Data Set
Train_X_vector = vectorizer.transform(X_train_data['CleanedText'].values)
# summarize encoded vector
print(Train_X_vector.shape)
```

```
(20834, 19971)
```

In [119]:
```
# Cross Validation Data Set
CV_X_vector = vectorizer.transform(X_cv_data['CleanedText'].values)
print(CV_X_vector.shape)
```

```
(4166, 19971)
```

In [120]:
```
#Test Data Set
Test_X_vector = vectorizer.transform(X_test_data['CleanedText'].values)
print(Test_X_vector.shape)
```
```
(5000, 19971)
```

In [121]:
```
print(Train_X_vector.shape)
print(CV_X_vector.shape)
print(Test_X_vector.shape)
print('-------------------')
print(Y_train.shape)
print(Y_cv.shape)
print(Y_test.shape)
```
```
(20834, 19971)
(4166, 19971)
(5000, 19971)
-------------------
(20834,)
(4166,)
(5000,)
```

In [122]:
```
svd = TruncatedSVD(n_components=50)
```

In [123]:
```
svd.fit(Train_X_vector)
```
Out[123]:
```
TruncatedSVD(algorithm='randomized', n_components=50, n_iter=5,
       random_state=None, tol=0.0)
```

In [124]:
```
TF_svd_Train=svd.transform(Train_X_vector)
```

In [125]:
```
TF_svd_Train.shape
```
Out[125]:
```
(20834, 50)
```

In [126]:
```
TF_svd_CV=svd.transform(CV_X_vector)
```

In [127]:
```
TF_svd_Test=svd.transform(Test_X_vector)
```

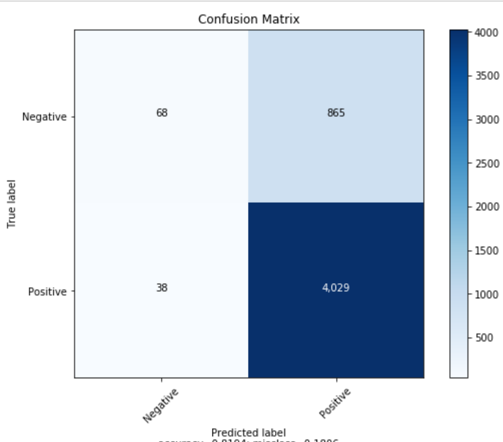
In [128]:
```
start_time_code = time.time()
for i in range(1,30,2):
    # instantiate learning model (k = 30)
    knn = KNeighborsClassifier(n_neighbors=i, algorithm="kd_tree")

    # fitting the model on crossvalidation train
    knn.fit(TF_svd_Train, Y_train)

    # predict the response on the crossvalidation train
    pred = knn.predict(TF_svd_CV)

    # evaluate CV accuracy
    bag_acc = accuracy_score(Y_cv, pred, normalize=True) * float(100)
    print('\nCV accuracy for k = %d is %0.1f%%' % (i, bag_acc))
end_time_code = time.time()
print ("Running Time for code execution " + str(end_time_code - start_time_code) + " secs")
```
```
CV accuracy for k = 1 is 77.8%

CV accuracy for k = 3 is 81.2%

CV accuracy for k = 5 is 82.3%

CV accuracy for k = 7 is 82.2%

CV accuracy for k = 9 is 82.6%

CV accuracy for k = 11 is 82.6%

CV accuracy for k = 13 is 82.5%

CV accuracy for k = 15 is 82.6%

CV accuracy for k = 17 is 82.5%

CV accuracy for k = 19 is 82.6%

CV accuracy for k = 21 is 82.7%

CV accuracy for k = 23 is 82.8%

CV accuracy for k = 25 is 82.8%

CV accuracy for k = 27 is 82.7%

CV accuracy for k = 29 is 82.7%
Running Time for code execution 174.01987504959106 secs
```

In [129]:
```
knn = KNeighborsClassifier(17,algorithm="kd_tree")
knn.fit(TF_svd_Train,Y_train)
pred = knn.predict(TF_svd_Test)
bag_test_acc = accuracy_score(Y_test, pred, normalize=True) * float(100)
print('\n****Test accuracy for k = 17 is %0.2f%%' % (bag_test_acc))
```
```
****Test accuracy for k = 17 is 81.94%
```

In [130]:
```
Conf_matrix=confusion_matrix(Y_test, pred)
```

In [131]:
```
Conf_matrix
```
Out[131]:
```
array([[  68,  865],
       [  38, 4029]])
```

In [132]:
```
plot_confusion_matrix(cm           = Conf_matrix,
                      normalize    = False,
                      target_names = ['Negative', 'Positive'],
                      title        = "Confusion Matrix")
```



In [133]:
```
TN,FP,FN,TP = Conf_matrix.ravel()
#confusion_matrix(Y_test, pred)
```

In [134]:
```
# Sensitivity, hit rate, recall, or true positive rate
TPR ='{0:.2%}'.format( TP/(TP+FN))
# Specificity or true negative rate
TNR ='{0:.2%}'.format( TN/(TN+FP))
# Fall out or false positive rate
FPR ='{0:.2%}'.format( FP/(FP+TN))
# False negative rate
FNR ='{0:.2%}'.format( FN/(TP+FN))
# Precision or positive predictive value
PPV ='{0:.2%}'.format( TP/(TP+FP))
# Negative predictive value
NPV ='{0:.2%}'.format( TN/(TN+FN))
# Overall accuracy
ACC ='{0:.2%}'.format( (TP+TN)/(TP+FP+FN+TN))
```

In [135]:
```
Recall=recall_score(Y_test, pred, average='micro')
```

In [136]:
```
Precision=precision_score(Y_test, pred, average='micro')
```

In [137]:
```
F1_Score=f1_score(Y_test, pred, average='weighted')
```

In [138]:
```
pd.crosstab(Y_test, pred, rownames=['True'], colnames=['Predicted'], margins=True)
```

Out[138]:

Predicted	negative	positive	All
True			
negative	68	865	933
positive	38	4029	4067
All	106	4894	5000

In [139]:
```
x.add_row(["Bag of Words","kd_tree",17,TPR,TNR,'{0:.2f}'.format(Precision),'{0:.2f}'.format(Recall),'{0:.2f}'.format(F1_Score),FPR,FNR,PPV,NPV,ACC])
```

In [140]:
```
print(x)
```

```
|    Model     | Algorithm |  K  |  TPR   |  TNR  | Precision | Recall | F1-Score |  FPR   |  FNR  |  PPV   |  NPV   | Overall Accuracy (ACC) |
| Bag of Words |  kd_tree  |  17 | 99.07% | 7.29% |    0.82   |  0.82  |   0.76   | 92.71% | 0.93% | 82.33% | 64.15% |         81.94%         |
```

In [141]:
```
print(classification_report(Y_test, pred))
```

```
             precision    recall  f1-score   support

   negative       0.64      0.07      0.13       933
   positive       0.82      0.99      0.90      4067

avg / total       0.79      0.82      0.76      5000
```

In [142]:
```
with open('Output_kd-tree.txt', 'w') as w:
    w.write(str(x))
```

TF - IDF

In [143]:
```
tf_transformer = TfidfVectorizer(ngram_range=(1,2))
TF_vector=tf_transformer.fit(X_train_data['CleanedText'].values)
TF_train_Vector = TF_vector.transform(X_train_data['CleanedText'].values)
TF_train_Vector.shape
```

Out[143]: (20834, 427963)

In [144]:
```
TF_cv_Vector = TF_vector.transform(X_cv_data['CleanedText'].values)
TF_cv_Vector.shape
```

Out[144]: (4166, 427963)

In [145]:
```
TF_test_Vector = TF_vector.transform(X_test_data['CleanedText'].values)
TF_test_Vector.shape
```

Out[145]: (5000, 427963)

In [146]:
```
print(TF_train_Vector.shape)
print(TF_cv_Vector.shape)
print(TF_test_Vector.shape)
print('-------------------')
print(Y_train.shape)
print(Y_cv.shape)
print(Y_test.shape)
```

```
(20834, 427963)
(4166, 427963)
(5000, 427963)
-------------------
(20834,)
(4166,)
(5000,)
```

In [147]:
```
svd = TruncatedSVD(n_components=20)
```

In [148]:
```
svd.fit(TF_train_Vector)
```

Out[148]:
```
TruncatedSVD(algorithm='randomized', n_components=20, n_iter=5,
       random_state=None, tol=0.0)
```

In [149]:
```
TF_svd_Train=svd.transform(TF_train_Vector)
```

In [150]:
```
TF_svd_Train.shape
```

Out[150]: (20834, 20)

In [151]:
```
TF_svd_CV=svd.transform(TF_cv_Vector)
```

In [152]:
```
TF_svd_Test=svd.transform(TF_test_Vector)
```

In [153]:

```
start_time_code = time.time()
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(TF_svd_Train, Y_train)

    # predict the response on the crossvalidation train
    pred = knn.predict(TF_svd_CV)

    # evaluate CV accuracy
    tf_acc = accuracy_score(Y_cv, pred, normalize=True) * float(100)
    print('\nCV accuracy for k = %d is %0.2f%%' % (i, tf_acc))
end_time_code = time.time()
print ("Running Time for code execution " + str(end_time_code - start_time_code) + " secs")
```

```
CV accuracy for k = 1 is 78.06%

CV accuracy for k = 3 is 81.04%

CV accuracy for k = 5 is 82.72%

CV accuracy for k = 7 is 82.53%

CV accuracy for k = 9 is 82.53%

CV accuracy for k = 11 is 82.55%

CV accuracy for k = 13 is 82.93%

CV accuracy for k = 15 is 82.74%

CV accuracy for k = 17 is 82.69%

CV accuracy for k = 19 is 82.81%

CV accuracy for k = 21 is 82.74%

CV accuracy for k = 23 is 82.84%

CV accuracy for k = 25 is 82.72%

CV accuracy for k = 27 is 82.81%

CV accuracy for k = 29 is 82.79%
Running Time for code execution 46.00462007522583 secs
```

In [154]:

```
knn = KNeighborsClassifier(17,algorithm="kd_tree")
knn.fit(TF_svd_Train,Y_train)
pred = knn.predict(TF_svd_Test)
tf_test_acc = accuracy_score(Y_test, pred, normalize=True) * float(100)
print('\n****Test accuracy for k = 17 is %0.2f%%' % (tf_test_acc))
```

```
****Test accuracy for k = 17 is 82.64%
```

In [155]:

```
Conf_matrix=confusion_matrix(Y_test, pred)
```

In [156]:

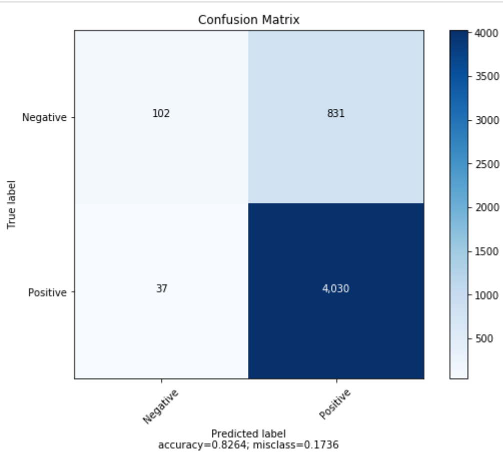
```
Conf_matrix
```

Out[156]:

```
array([[ 102,  831],
       [  37, 4030]])
```

In [157]:

```
plot_confusion_matrix(cm           = Conf_matrix,
                      normalize    = False,
                      target_names = ['Negative', 'Positive'],
                      title        = "Confusion Matrix")
```



In [158]:

```
TN,FP,FN,TP = Conf_matrix.ravel()
#confusion_matrix(Y_test, pred)
```

In [159]:

```
# Sensitivity, hit rate, recall, or true positive rate
TPR ='{0:.2%}'.format( TP/(TP+FN))
# Specificity or true negative rate
TNR ='{0:.2%}'.format( TN/(TN+FP))
# Fall out or false positive rate
FPR ='{0:.2%}'.format( FP/(FP+TN))
# False negative rate
FNR ='{0:.2%}'.format( FN/(TP+FN))
# Precision or positive predictive value
PPV ='{0:.2%}'.format( TP/(TP+FP))
# Negative predictive value
NPV ='{0:.2%}'.format( TN/(TN+FN))
# Overall accuracy
ACC ='{0:.2%}'.format( (TP+TN)/(TP+FP+FN+TN))
```

In [160]:

```
Recall=recall_score(Y_test, pred, average='micro')
```

In [161]:

```
Precision=precision_score(Y_test, pred, average='micro')
```

In [162]:

```
F1_Score=f1_score(Y_test, pred, average='weighted')
```

In [163]:

```
pd.crosstab(Y_test, pred, rownames=['True'], colnames=['Predicted'], margins=True)
```

Out[163]:

Predicted	negative	positive	All
True			
negative	102	831	933
positive	37	4030	4067
All	139	4861	5000

In [164]:

```
x.add_row([" TF - IDF ","Kd_tree",17,TPR,TNR,'{0:.2f}'.format(Precision),'{0:.2f}'.format(Recall),'{0:.2f}'.format(F1_Score),FPR,FNR,PPV,NPV,ACC])
```

In [165]:

```
print(classification_report(Y_test, pred))
```

```
             precision    recall  f1-score   support

   negative       0.73      0.11      0.19       933
   positive       0.83      0.99      0.90      4067

avg / total       0.81      0.83      0.77      5000
```

In [166]:
```
print(x)
```

Model	Algorithm	K	TPR	TNR	Precision	Recall	F1-Score	FPR	FNR	PPV	NPV	Overall Accuracy (ACC)
Bag of Words	kd_tree	17	99.07%	7.29%	0.82	0.82	0.76	92.71%	0.93%	82.33%	64.15%	81.94%
TF - IDF	Kd_tree	13	99.09%	10.93%	0.83	0.83	0.77	89.07%	0.91%	82.90%	73.38%	82.64%

Average W2V

In [167]:
```
# Train your own Word2Vec model using your own text corpus for Training Dataset
i=0
list_of_sent=[]
for sent in X_train_data['CleanedText'].values:
    list_of_sent.append(sent.split())

# min_count = 5 considers only words that occured atleast 5 times
Trained_model=Word2Vec(list_of_sent,min_count=5,size=50, workers=4)

w2v_words = list(Trained_model.wv.vocab)
print("number of words that occured minimum 5 times ",len(w2v_words))
print("sample words ", w2v_words[0:50])
```

```
number of words that occured minimum 5 times  6969
sample words  ['littl', 'book', 'make', 'son', 'laugh', 'loud', 'car', 'drive', 'along', 'alway', 'sing', 'refrain', 'hes', 'learn', 'india', 'love', 'new', 'wo
rd', 'introduc', 'silli', 'classic', 'will', 'bet', 'still', 'abl', 'memori', 'colleg', 'rememb', 'see', 'show', 'air', 'televis', 'year', 'ago', 'child', 'sist
er', 'later', 'bought', 'day', 'thirti', 'someth', 'use', 'seri', 'song', 'student', 'teach', 'turn', 'whole', 'school', 'purchas']
```

In [168]:
```
# average Word2Vec
# compute average word2vec for each review.
Trained_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 = Trained_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    Trained_vectors.append(sent_vec)
print(len(Trained_vectors))
```

```
20834
```

In [169]:
```
Train_X=Trained_vectors
```

In [170]:
```
# Train your own Word2Vec model using your own text corpus
i=0
list_of_sent_cv=[]
for sent in X_cv_data['CleanedText'].values:
    list_of_sent_cv.append(sent.split())
```

In [171]:
```
# average Word2Vec
# compute average word2vec for each review.
Cv_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sent in list_of_sent_cv: # 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 = Trained_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    Cv_vectors.append(sent_vec)
print(len(Cv_vectors))
```

```
4166
```

In [172]:
```
CV_X=Cv_vectors
```

In [173]:
```
# Train your own Word2Vec model using your own text corpus
i=0
list_of_sent_test=[]
for sent in X_test_data['CleanedText'].values:
    list_of_sent_test.append(sent.split())
```

In [174]:
```
# average Word2Vec
# compute average word2vec for each review.
test_vectors = []; # the avg-w2v for each sentence/review is stored in this list
for sent in list_of_sent_test: # 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 = Trained_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    test_vectors.append(sent_vec)
print(len(test_vectors))
```

```
5000
```

In [175]:
```
Test_X=test_vectors
```

In [176]:
```
print (len(Train_X))
print(len(CV_X))
print(len(Test_X))
print('-----------------')
print (Y_train.shape)
print(Y_cv.shape)
print(Y_test.shape)
```

```
20834
4166
5000
-----------------
(20834,)
(4166,)
(5000,)
```

In [177]:
```
start_time_code = time.time()
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_X, Y_train)

    # predict the response on the crossvalidation train
    pred = knn.predict(CV_X)

    # evaluate CV accuracy
    train_acc = accuracy_score(Y_cv, pred, normalize=True) * float(100)
    print('\nCV accuracy for k = %d is %0.2f%%' % (i, train_acc))
end_time_code = time.time()
print ("Running Time for code execution " + str(end_time_code - start_time_code) + " secs")
```

```
CV accuracy for k = 1 is 79.28%

CV accuracy for k = 3 is 82.45%

CV accuracy for k = 5 is 83.39%

CV accuracy for k = 7 is 83.27%

CV accuracy for k = 9 is 83.22%

CV accuracy for k = 11 is 83.44%

CV accuracy for k = 13 is 83.34%

CV accuracy for k = 15 is 83.41%

CV accuracy for k = 17 is 83.39%

CV accuracy for k = 19 is 83.27%

CV accuracy for k = 21 is 83.34%

CV accuracy for k = 23 is 83.37%

CV accuracy for k = 25 is 83.29%

CV accuracy for k = 27 is 83.29%

CV accuracy for k = 29 is 83.27%
Running Time for code execution 153.1801438331604 secs
```

In [178]:
```
# Since the train accuracy for k is the same from k=3 to k=29. so the smallest k at maximum accuracy is the best i.e. k=3
knn = KNeighborsClassifier(11,algorithm="kd_tree")
knn.fit(Train_X,Y_train)
pred = knn.predict(Test_X)
test_acc = accuracy_score(Y_test, pred, normalize=True) * float(100)
print('\n****Test accuracy for k = 11 is %0.2f%%' % (test_acc))
```

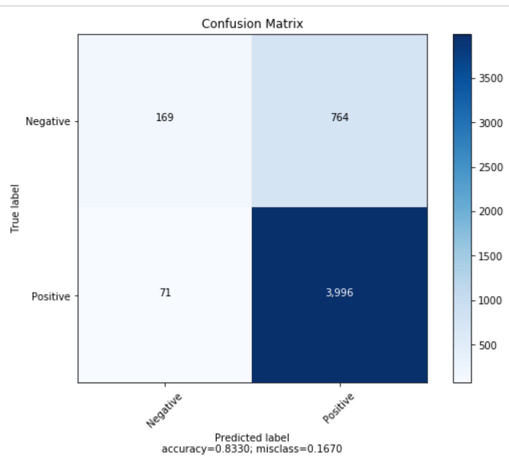
```
****Test accuracy for k = 11 is 83.30%
```

In [179]:
```
Conf_matrix=confusion_matrix(Y_test, pred)
```

In [180]:
```
Conf_matrix
```

Out[180]:
```
array([[ 169,  764],
       [  71, 3996]])
```

In [181]:
```
plot_confusion_matrix(cm           = Conf_matrix,
                      normalize    = False,
                      target_names = ['Negative', 'Positive'],
                      title        = "Confusion Matrix")
```



In [182]:
```
TN,FP,FN,TP = Conf_matrix.ravel()
#confusion_matrix(Y_test, pred)
```

In [183]:
```
# Sensitivity, hit rate, recall, or true positive rate
TPR ='{0:.2%}'.format( TP/(TP+FN))
# Specificity or true negative rate
TNR ='{0:.2%}'.format( TN/(TN+FP))
# Fall out or false positive rate
FPR ='{0:.2%}'.format( FP/(FP+TN))
# False negative rate
FNR ='{0:.2%}'.format( FN/(TP+FN))
# Precision or positive predictive value
PPV ='{0:.2%}'.format( TP/(TP+FP))
# Negative predictive value
NPV ='{0:.2%}'.format( TN/(TN+FN))
# Overall accuracy
ACC ='{0:.2%}'.format( (TP+TN)/(TP+FP+FN+TN))
```

In [184]:
```
Recall=recall_score(Y_test, pred, average='micro')
```

In [185]:
```
Precision=precision_score(Y_test, pred, average='micro')
```

In [186]:
```
F1_Score=f1_score(Y_test, pred, average='weighted')
```

In [187]:
```
pd.crosstab(Y_test, pred, rownames=['True'], colnames=['Predicted'], margins=True)
```

Out[187]:

Predicted True	negative	positive	All
negative	169	764	933
positive	71	3996	4067
All	240	4760	5000

In [188]:
```
x.add_row([" Average W2V ","Kd_tree",11,TPR,TNR,'{0:.2f}'.format(Precision),'{0:.2f}'.format(Recall),'{0:.2f}'.format(F1_Score),FPR,FNR,PPV,NPV,ACC])
```

In [189]:
```
print(classification_report(Y_test, pred))
```

```
             precision    recall  f1-score   support

   negative       0.70      0.18      0.29       933
   positive       0.84      0.98      0.91      4067

avg / total       0.81      0.83      0.79      5000
```

In [190]:
```
print(x)
```

```
|     Model     | Algorithm | K  |  TPR   |  TNR   | Precision | Recall | F1-Score |  FPR   |  FNR  |  PPV   |  NPV   | Overall Accuracy (ACC) |
|  Bag of Words |  kd_tree  | 17 | 99.07% | 7.29%  |    0.82   |  0.82  |   0.76   | 92.71% | 0.93% | 82.33% | 64.15% |         81.94%         |
|    TF - IDF   |  Kd_tree  | 13 | 99.09% | 10.93% |    0.83   |  0.83  |   0.77   | 89.07% | 0.91% | 82.90% | 73.38% |         82.64%         |
|  Average W2V  |  Kd_tree  | 11 | 98.25% | 18.11% |    0.83   |  0.83  |   0.79   | 81.89% | 1.75% | 83.95% | 70.42% |         83.30%         |
```

TF-IDF weighted Word2Vec

In [53]:
```
# TF-IDF weighted Word2Vec
tfidf_feat = TF_vector.get_feature_names() # tfidf words/col-names
```

In [54]:
```
# final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = tfidf
start_time_code = time.time()
tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in this list
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 = Trained_model.wv[word]
            # obtain the tf_idfidf of a word in a sentence/review
            tf_idf = TF_train_Vector[row, tfidf_feat.index(word)]
            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
end_time_code = time.time()
print ("Running Time for code execution " + str(end_time_code - start_time_code) + " secs")
```

```
Running Time for code execution 13474.992048978806 secs
```

In [55]:
```
Train_X=tfidf_sent_vectors
```

In [56]:
```
df = pd.DataFrame.from_records(Train_X)
df.to_csv('TF-IDF_W2V_Train_kd.csv',index=None)
```

In [191]:
```
Train_X = pd.read_csv("TF-IDF_W2V_Train_kd.csv")
```

In [57]:
```
# final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = tfidf
start_time_code = time.time()
tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in this list
row=0;
for sent in list_of_sent_cv: # 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 = Trained_model.wv[word]
            # obtain the tf_idfidf of a word in a sentence/review
            tf_idf = TF_cv_Vector[row, tfidf_feat.index(word)]
            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
end_time_code = time.time()
print ("Running Time for code execution " + str(end_time_code - start_time_code) + " secs")
```

```
Running Time for code execution 2435.09094786644 secs
```

In [58]:
```
CV_X=tfidf_sent_vectors
```

In [59]:
```
df = pd.DataFrame.from_records(CV_X)
df.to_csv('TF-IDF_W2V_CV_Kd.csv',index=None)
```

In [192]:
```
CV_X = pd.read_csv("TF-IDF_W2V_CV_Kd.csv")
```

In [60]:
```
# final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = tfidf
start_time_code = time.time()
tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored in this list
row=0;
for sent in list_of_sent_test: # 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 = Trained_model.wv[word]
            # obtain the tf_idfidf of a word in a sentence/review
            tf_idf = TF_test_Vector[row, tfidf_feat.index(word)]
            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
end_time_code = time.time()
print ("Running Time for code execution " + str(end_time_code - start_time_code) + " secs")
```

```
Running Time for code execution 2871.7937688827515 secs
```

In [61]:
```
Test_X=tfidf_sent_vectors
```

In [62]:
```
df = pd.DataFrame.from_records(Test_X)
df.to_csv('TF-IDF_W2V_Test_Kd.csv',index=None)
```

In [193]:
```
Test_X = pd.read_csv("TF-IDF_W2V_Test_Kd.csv")
```

In [194]:
```
start_time_code = time.time()
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_X, Y_train)

    # predict the response on the crossvalidation train
    pred = knn.predict(CV_X)

    # evaluate CV accuracy
    train_acc = accuracy_score(Y_cv, pred, normalize=True) * float(100)
    print('\nCV accuracy for k = %d is %0.2f%%' % (i, train_acc))
end_time_code = time.time()
print ("Running Time for code execution " + str(end_time_code - start_time_code) + " secs")
```

```
CV accuracy for k = 1 is 77.87%

CV accuracy for k = 3 is 81.06%

CV accuracy for k = 5 is 82.53%

CV accuracy for k = 7 is 82.67%

CV accuracy for k = 9 is 83.37%

CV accuracy for k = 11 is 83.15%

CV accuracy for k = 13 is 83.08%

CV accuracy for k = 15 is 82.89%

CV accuracy for k = 17 is 82.89%

CV accuracy for k = 19 is 82.93%

CV accuracy for k = 21 is 82.89%

CV accuracy for k = 23 is 82.93%

CV accuracy for k = 25 is 82.91%

CV accuracy for k = 27 is 83.03%

CV accuracy for k = 29 is 82.86%
Running Time for code execution 135.67332410812378 secs
```

In [195]:
```
# Since the train accuracy for k is the same from k=3 to k=29. so the smallest k at maximum accuracy is the best i.e. k=3
knn = KNeighborsClassifier(23,algorithm="kd_tree")
knn.fit(Train_X,Y_train)
pred = knn.predict(Test_X)
test_acc = accuracy_score(Y_test, pred, normalize=True) * float(100)
print('\n****Test accuracy for k = 23 is %0.2f%%' % (test_acc))
```

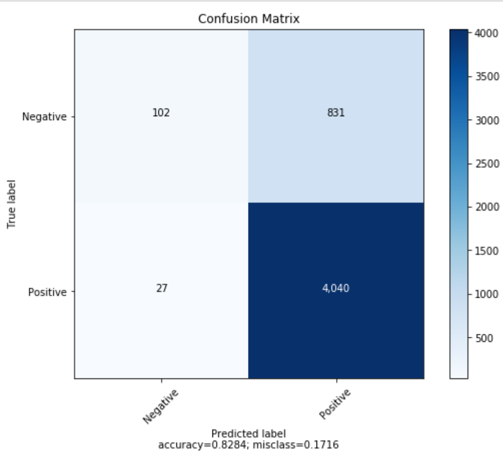
```
****Test accuracy for k = 23 is 82.84%
```

In [196]:
```
Conf_matrix=confusion_matrix(Y_test, pred)
```

In [197]:
```
Conf_matrix
```

Out[197]:
```
array([[ 102,  831],
       [  27, 4040]])
```

In [198]:
```
plot_confusion_matrix(cm           = Conf_matrix,
                      normalize    = False,
                      target_names = ['Negative', 'Positive'],
                      title        = "Confusion Matrix")
```



In [199]:
```
TN,FP,FN,TP = Conf_matrix.ravel()
#confusion_matrix(Y_test, pred)
```

In [200]:
```
# Sensitivity, hit rate, recall, or true positive rate
TPR ='{0:.2%}'.format( TP/(TP+FN))
# Specificity or true negative rate
TNR ='{0:.2%}'.format( TN/(TN+FP))
# Fall out or false positive rate
FPR ='{0:.2%}'.format( FP/(FP+TN))
# False negative rate
FNR ='{0:.2%}'.format( FN/(TP+FN))
# Precision or positive predictive value
PPV ='{0:.2%}'.format( TP/(TP+FP))
# Negative predictive value
NPV ='{0:.2%}'.format( TN/(TN+FN))
# Overall accuracy
ACC ='{0:.2%}'.format( (TP+TN)/(TP+FP+FN+TN))
```

In [201]:
```
Recall=recall_score(Y_test, pred, average='micro')
```

In [202]:
```
Precision=precision_score(Y_test, pred, average='micro')
```

In [203]:
```
F1_Score=f1_score(Y_test, pred, average='weighted')
```

In [204]:
```
pd.crosstab(Y_test, pred, rownames=['True'], colnames=['Predicted'], margins=True)
```

Out[204]:

Predicted	negative	positive	All
True			
negative	102	831	933
positive	27	4040	4067
All	129	4871	5000

In [205]:
```
x.add_row([" TF - IDF Weighted W2V ","Kd_tree",23,TPR,TNR,'{0:.2f}'.format(Precision),'{0:.2f}'.format(Recall),'{0:.2f}'.format(F1_Score),FPR,FNR,PPV,NPV,ACC])
```

In [206]:
```
print(classification_report(Y_test, pred))
```

```
             precision    recall  f1-score   support

   negative       0.79      0.11      0.19       933
   positive       0.83      0.99      0.90      4067

avg / total       0.82      0.83      0.77      5000
```

In [299]:
```
print(x)
```

Model	Algorithm	K	TPR	TNR	Precision	Recall	F1-Score	FPR	FNR	PPV	NPV	Overall Accuracy (ACC)
Bag of Words	kd_tree	17	99.07%	7.29%	0.82	0.82	0.76	92.71%	0.93%	82.33%	64.15%	81.94%
TF - IDF	Kd_tree	13	99.09%	10.93%	0.83	0.83	0.77	89.07%	0.91%	82.90%	73.38%	82.64%
Average W2V	Kd_tree	11	98.25%	18.11%	0.83	0.83	0.79	81.89%	1.75%	83.95%	70.42%	83.30%
TF - IDF Weighted W2V	Kd_tree	23	99.34%	10.93%	0.83	0.83	0.77	89.07%	0.66%	82.94%	79.07%	82.84%
Bag of Words	Brute	15	99.93%	1.87%	0.82	0.82	0.74	98.13%	0.07%	81.68%	85.29%	81.70%
TF - IDF	Brute	11	99.04%	12.27%	0.83	0.83	0.78	87.73%	0.96%	83.18%	74.51%	82.91%
Average W2V	Brute	17	98.36%	20.85%	0.84	0.84	0.80	79.15%	1.64%	84.48%	74.42%	83.96%
TF-IDF Weighted W2V	Brute	17	98.88%	2.07%	0.81	0.81	0.73	97.93%	1.12%	81.56%	29.63%	80.88%

In [300]:
```
with open('Output.txt', 'w') as w:
    w.write(str(x))
```

Conclusion

1. Of all the Word to vector conversion models, TF - IDF got more True Positive Rate and True Negative Rate in 'Brute' and 'Kd-tree'