Amazon Fine Food Reviews Analysis

Data Source: https://www.kaggle.com/snap/amazon-fine-food-reviews

EDA: https://nycdatascience.com/blog/student-works/amazon-fine-foods-visualization/

The Amazon Fine Food Reviews dataset consists of reviews of fine foods from Amazon.

Number of reviews: 568,454
Number of users: 256,059
Number of products: 74,258
Timespan: Oct 1999 - Oct 2012
Number of Attributes/Columns in data: 10

Attribute Information:

1. Id
2. ProductId - unique identifier for the product
3. UserId - unqiue identifier for the user
4. ProfileName
5. HelpfulnessNumerator - number of users who found the review helpful
6. HelpfulnessDenominator - number of users who indicated whether they found the review helpful or not
7. Score - rating between 1 and 5
8. Time - timestamp for the review
9. Summary - brief summary of the review
10. Text - text of the review

Objective:

Given a review, determine whether the review is positive (rating of 4 or 5) or negative (rating of 1 or 2).

[Q] How to determine if a review is positive or negative?

[Ans] We could use Score/Rating. A rating of 4 or 5 can be cosnidered as a positive review. A rating of 1 or 2 can be considered as negative one. A review of rating 3 is considered nuetral and such reviews are ignored from our analysis. This is an approximate and proxy way of determining the polarity (positivity/negativity) of a review.

[1]. Reading Data

[1.1] Loading the data

The dataset is available in two forms

1. .csv file
2. SQLite Database

In order to load the data, We have used the SQLITE dataset as it is easier to query the data and visualise the data efficiently.

Here as we only want to get the global sentiment of the recommendations (positive or negative), we will purposefully ignore all Scores equal to 3. If the score is above 3, then the recommendation wil be set to "positive". Otherwise, it will be set to "negative".

In [1]:
```
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")


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 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 Word2Vec
from gensim.models import KeyedVectors
import pickle

from tqdm import tqdm
import os
```

```
C:\Users\hemant\Anaconda\lib\site-packages\gensim\utils.py:1209: UserWa
rning: detected Windows; aliasing chunkize to chunkize_serial
  warnings.warn("detected Windows; aliasing chunkize to chunkize_seria
l")
```

In [2]:

```
# using SQLite Table to read data.
con = sqlite3.connect(r'G:\database_assignment\Logistic_regression\data
base5.sqlite')
# filtering only positive and negative reviews i.e.
# not taking into consideration those reviews with Score=3
# SELECT * FROM Reviews WHERE Score != 3 LIMIT 500000, will give top 50
0000 data points
# you can change the number to any other number based on your computing
 power
```

```
# filtered_data = pd.read_sql_query(""" SELECT * FROM Reviews WHERE Sco
re != 3 LIMIT 500000""", con)
# for tsne assignment you can take 5k data points

filtered_data = pd.read_sql_query(""" SELECT * FROM Reviews WHERE Score
 != 3 """, con)

# Give reviews with Score>3 a positive rating(1), and reviews with a sc
ore<3 a negative rating(0).
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("Number of data points in our data", filtered_data.shape)
filtered_data.head(3)
```

```
Number of data points in our data (525814, 10)
```

Out[2]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	Helpfulnes
0	1	B001E4KFG0	A3SGXH7AUHU8GW	delmartian	1	1

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	Helpfulnes
1	2	B00813GRG4	A1D87F6ZCVE5NK	dll pa	0	0
2	3	B000LQOCH0	ABXLMWJIXXAIN	Natalia Corres "Natalia Corres"	1	1

In [3]:
```
display = pd.read_sql_query("""
SELECT UserId, ProductId, ProfileName, Time, Score, Text, COUNT(*)
FROM Reviews
GROUP BY UserId
HAVING COUNT(*)>1
""", con)
```

In [4]:
```
print(display.shape)
display.head()
```

```
(80668, 7)
```

Out[4]:

	UserId	ProductId	ProfileName	Time	Score	Text	COU

	UserId	ProductId	ProfileName	Time	Score	Text	COUI
0	#oc-R115TNMSPFT9I7	B007Y59HVM	Breyton	1331510400	2	Overall its just OK when considering the price...	2
1	#oc-R11D9D7SHXIJB9	B005HG9ET0	Louis E. Emory "hoppy"	1342396800	5	My wife has recurring extreme muscle spasms, u...	3
2	#oc-R11DNU2NBKQ23Z	B007Y59HVM	Kim Cieszykowski	1348531200	1	This coffee is horrible and unfortunately not ...	2
3	#oc-R11O5J5ZVQE25C	B005HG9ET0	Penguin Chick	1346889600	5	This will be the bottle that you grab from the...	3
4	#oc-R12KPBODL2B5ZD	B007OSBE1U	Christopher P. Presta	1348617600	1	I didnt like this coffee. Instead of telling y...	2

In [5]:
```
display[display['UserId']=='AZY10LLTJ71NX']
```

Out[5]:

	UserId	ProductId	ProfileName	Time	Score	Text	C

	UserId	ProductId	ProfileName	Time	Score	Text
80638	AZY10LLTJ71NX	B006P7E5ZI	undertheshrine "undertheshrine"	1334707200	5	I was recommended to try green tea extract to ...

In [6]:
```
display['COUNT(*)'].sum()
```

Out[6]:
```
393063
```

[2] Exploratory Data Analysis

[2.1] Data Cleaning: Deduplication

It is observed (as shown in the table below) that the reviews data had many duplicate entries. Hence it was necessary to remove duplicates in order to get unbiased results for the analysis of the data. Following is an example:

In [7]:
```
display= pd.read_sql_query("""
SELECT *
FROM Reviews
WHERE Score != 3 AND UserId="AR5J8UI46CURR"
ORDER BY ProductID
""", con)
display.head()
```

Out[7]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	Helpfuln

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulN
0	78445	B000HDL1RQ	AR5J8UI46CURR	Geetha Krishnan	2	2
1	138317	B000HDOPYC	AR5J8UI46CURR	Geetha Krishnan	2	2
2	138277	B000HDOPYM	AR5J8UI46CURR	Geetha Krishnan	2	2
3	73791	B000HDOPZG	AR5J8UI46CURR	Geetha Krishnan	2	2
4	155049	B000PAQ75C	AR5J8UI46CURR	Geetha Krishnan	2	2

As it can be seen above that same user has multiple reviews with same values for HelpfulnessNumerator, HelpfulnessDenominator, Score, Time, Summary and Text and on doing analysis it was found that

ProductId=B000HDOPZG was Loacker Quadratini Vanilla Wafer Cookies, 8.82-Ounce Packages (Pack of 8)

ProductId=B000HDL1RQ was Loacker Quadratini Lemon Wafer Cookies, 8.82-Ounce Packages (Pack of 8) and so on

It was inferred after analysis that reviews with same parameters other than ProductId belonged to the same product just having different flavour or quantity. Hence in order to reduce redundancy it was decided to eliminate the rows having same parameters.

The method used for the same was that we first sort the data according to ProductId and then just keep the first similar product review and delelte the others. for eg. in the above just the review for ProductId=B000HDL1RQ remains. This method ensures that there is only one representative for each product and deduplication without sorting would lead to possibility of different representatives still existing for the same product.

In [8]:
```
#Sorting data according to ProductId in ascending order
sorted_data=filtered_data.sort_values('ProductId', axis=0, ascending=True, inplace=False, kind='quicksort', na_position='last')
```

In [9]:
```
#Deduplication of entries
final=sorted_data.drop_duplicates(subset={"UserId","ProfileName","Time","Text"}, keep='first', inplace=False)
final.shape
```

Out[9]:
```
(364173, 10)
```

In [10]:
```
#Checking to see how much % of data still remains
(final['Id'].size*1.0)/(filtered_data['Id'].size*1.0)*100
```

Out[10]:
```
69.25890143662969
```

Observation:- It was also seen that in two rows given below the value of HelpfulnessNumerator is greater than HelpfulnessDenominator which is not practically possible hence these two rows too are removed from calcualtions

In [11]:
```
display= pd.read_sql_query("""
SELECT *
FROM Reviews
WHERE Score != 3 AND Id=44737 OR Id=64422
ORDER BY ProductID
""", con)

display.head()
```

Out[11]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulIn
0	64422	B000MIDROQ	A161DK06JJMCYF	J. E. Stephens "Jeanne"	3	1
1	44737	B001EQ55RW	A2V0I904FH7ABY	Ram	3	2

In [12]:
```
final=final[final.HelpfulnessNumerator<=final.HelpfulnessDenominator]
```

In [13]:
```
#Before starting the next phase of preprocessing lets see the number of
 entries left
print(final.shape)
```

```
#How many positive and negative reviews are present in our dataset?
final['Score'].value_counts()
```

```
(364171, 10)
```

Out[13]:
```
1    307061
0     57110
Name: Score, dtype: int64
```

[3] Preprocessing

[3.1]. Preprocessing Review Text

Now that we have finished deduplication our data requires some preprocessing before we go on further with analysis and making the prediction model.

Hence in the Preprocessing phase we do the following in the order below:-

1. Begin by removing the html tags
2. Remove any punctuations or limited set of special characters like , or . or # etc.
3. Check if the word is made up of english letters and is not alpha-numeric
4. Check to see if the length of the word is greater than 2 (as it was researched that there is no adjective in 2-letters)
5. Convert the word to lowercase
6. Remove Stopwords
7. Finally Snowball Stemming the word (it was obsereved to be better than Porter Stemming)

After which we collect the words used to describe positive and negative reviews

In [14]:
```
# printing some random reviews
sent_0 = final['Text'].values[0]
print(sent_0)
print("="*50)
```

```
sent_1000 = final['Text'].values[1000]
print(sent_1000)
print("="*50)

sent_1500 = final['Text'].values[1500]
print(sent_1500)
print("="*50)

sent_4900 = final['Text'].values[4900]
print(sent_4900)
print("="*50)
```

```
this witty little book makes my son laugh at loud. i recite it in the c
ar as we're driving along and he always can sing the refrain. he's lear
ned about whales, India, drooping roses:  i love all the new words this
book  introduces and the silliness of it all.  this is a classic book i
am  willing to bet my son will STILL be able to recite from memory when
he is  in college
==================================================
I was really looking forward to these pods based on the reviews.  Starb
ucks is good, but I prefer bolder taste.... imagine my surprise when I
ordered 2 boxes - both were expired! One expired back in 2005 for gosh
sakes.  I admit that Amazon agreed to credit me for cost plus part of s
hipping, but geez, 2 years expired!!!  I'm hoping to find local San Die
go area shoppe that carries pods so that I can try something different
than starbucks.
==================================================
Great ingredients although, chicken should have been 1st rather than ch
icken broth, the only thing I do not think belongs in it is Canola oil.
Canola or rapeseed is not someting a dog would ever find in nature and
if it did find rapeseed in nature and eat it, it would poison them. Tod
ay's Food industries have convinced the masses that Canola oil is a saf
e and even better oil than olive or virgin coconut, facts though say ot
herwise. Until the late 70's it was poisonous until they figured out a
way to fix that. I still like it but it could be better.
==================================================
Can't do sugar.  Have tried scores of SF Syrups.  NONE of them can touc
h the excellence of this product.<br /><br />Thick, delicious.  Perfec
t.  3 ingredients: Water, Maltitol, Natural Maple Flavor.  PERIOD.  No

chemicals.  No garbage.<br /><br />Have numerous friends & family membe
```

```
chemicals.  No garbage.<br /><br />Have numerous friends & family membe
rs hooked on this stuff.  My husband & son, who do NOT like "sugar fre
e" prefer this over major label regular syrup.<br /><br />I use this as
my SWEETENER in baking: cheesecakes, white brownies, muffins, pumpkin p
ies, etc... Unbelievably delicious...<br /><br />Can you tell I like i
t? :)
==================================================
```

In [15]:
```
# remove urls from text python: https://stackoverflow.com/a/40823105/40
84039
sent_0 = re.sub(r"http\S+", "", sent_0)
sent_1000 = re.sub(r"http\S+", "", sent_1000)
sent_150 = re.sub(r"http\S+", "", sent_1500)
sent_4900 = re.sub(r"http\S+", "", sent_4900)

print(sent_0)
```

```
this witty little book makes my son laugh at loud. i recite it in the c
ar as we're driving along and he always can sing the refrain. he's lear
ned about whales, India, drooping roses:  i love all the new words this
book  introduces and the silliness of it all.  this is a classic book i
am  willing to bet my son will STILL be able to recite from memory when
he is  in college
```

In [16]:
```
# https://stackoverflow.com/questions/16206380/python-beautifulsoup-how
-to-remove-all-tags-from-an-element
from bs4 import BeautifulSoup

soup = BeautifulSoup(sent_0, 'lxml')
text = soup.get_text()
print(text)
print("="*50)

soup = BeautifulSoup(sent_1000, 'lxml')
text = soup.get_text()
print(text)
print("="*50)

soup = BeautifulSoup(sent_1500, 'lxml')
```

```
text = soup.get_text()
print(text)
print("="*50)

soup = BeautifulSoup(sent_4900, 'lxml')
text = soup.get_text()
print(text)
```

```
this witty little book makes my son laugh at loud. i recite it in the c
ar as we're driving along and he always can sing the refrain. he's lear
ned about whales, India, drooping roses:  i love all the new words this
book  introduces and the silliness of it all.  this is a classic book i
am  willing to bet my son will STILL be able to recite from memory when
he is  in college
==================================================
I was really looking forward to these pods based on the reviews.  Starb
ucks is good, but I prefer bolder taste.... imagine my surprise when I
ordered 2 boxes - both were expired! One expired back in 2005 for gosh
sakes.  I admit that Amazon agreed to credit me for cost plus part of s
hipping, but geez, 2 years expired!!!  I'm hoping to find local San Die
go area shoppe that carries pods so that I can try something different
than starbucks.
==================================================
Great ingredients although, chicken should have been 1st rather than ch
icken broth, the only thing I do not think belongs in it is Canola oil.
Canola or rapeseed is not someting a dog would ever find in nature and
if it did find rapeseed in nature and eat it, it would poison them. Tod
ay's Food industries have convinced the masses that Canola oil is a saf
e and even better oil than olive or virgin coconut, facts though say ot
herwise. Until the late 70's it was poisonous until they figured out a
way to fix that. I still like it but it could be better.
==================================================
Can't do sugar.  Have tried scores of SF Syrups.  NONE of them can touc
h the excellence of this product.Thick, delicious.  Perfect.  3 ingredi
ents: Water, Maltitol, Natural Maple Flavor.  PERIOD.  No chemicals.  N
o garbage.Have numerous friends & family members hooked on this stuff.
My husband & son, who do NOT like "sugar free" prefer this over major l
abel regular syrup.I use this as my SWEETENER in baking: cheesecakes, w

hite brownies, muffins, pumpkin pies, etc... Unbelievably delicious...C
```

```
an you tell I like it? :)
```

In [17]:
```
# https://stackoverflow.com/a/47091490/4084039
import re

def decontracted(phrase):
    # specific
    phrase = re.sub(r"won't", "will not", phrase)
    phrase = re.sub(r"can\'t", "can not", phrase)

    # general
    phrase = re.sub(r"n\'t", " not", phrase)
    phrase = re.sub(r"\'re", " are", phrase)
    phrase = re.sub(r"\'s", " is", phrase)
    phrase = re.sub(r"\'d", " would", phrase)
    phrase = re.sub(r"\'ll", " will", phrase)
    phrase = re.sub(r"\'t", " not", phrase)
    phrase = re.sub(r"\'ve", " have", phrase)
    phrase = re.sub(r"\'m", " am", phrase)
    return phrase
```

In [18]:
```
sent_1500 = decontracted(sent_1500)
print(sent_1500)
print("="*50)
```

```
Great ingredients although, chicken should have been 1st rather than ch
icken broth, the only thing I do not think belongs in it is Canola oil.
Canola or rapeseed is not someting a dog would ever find in nature and
if it did find rapeseed in nature and eat it, it would poison them. Tod
ay is Food industries have convinced the masses that Canola oil is a sa
fe and even better oil than olive or virgin coconut, facts though say o
therwise. Until the late 70 is it was poisonous until they figured out
a way to fix that. I still like it but it could be better.
==================================================
```

In [19]:
```
#remove words with numbers python: https://stackoverflow.com/a/1808237
0/4084039
```

```
sent_0 = re.sub("\S*\d\S*", "", sent_0).strip()
print(sent_0)
```

```
this witty little book makes my son laugh at loud. i recite it in the c
ar as we're driving along and he always can sing the refrain. he's lear
ned about whales, India, drooping roses:  i love all the new words this
book  introduces and the silliness of it all.  this is a classic book i
am  willing to bet my son will STILL be able to recite from memory when
he is  in college
```

In [20]:
```
#remove spacial character: https://stackoverflow.com/a/5843547/4084039
sent_1500 = re.sub('[^A-Za-z0-9]+', ' ', sent_1500)
print(sent_1500)
```

```
Great ingredients although chicken should have been 1st rather than chi
cken broth the only thing I do not think belongs in it is Canola oil Ca
nola or rapeseed is not someting a dog would ever find in nature and if
it did find rapeseed in nature and eat it it would poison them Today is
Food industries have convinced the masses that Canola oil is a safe and
even better oil than olive or virgin coconut facts though say otherwise
Until the late 70 is it was poisonous until they figured out a way to f
ix that I still like it but it could be better
```

In [21]:
```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'no
t'
# <br /><br /> ==> after the above steps, we are getting "br br"
# we are including them into stop words list
# instead of <br /> if we have <br/> these tags would have revmoved in
 the 1st step

stopwords= set(['br', 'the', 'i', 'me', 'my', 'myself', 'we', 'our', 'o
urs', 'ourselves', 'you', "you're", "you've",\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselve
s', 'he', 'him', 'his', 'himself', \
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'it
s', 'itself', 'they', 'them', 'their',\
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'th
is', 'that', "that'll", 'these', 'those', \
```

```
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'h
ave', 'has', 'had', 'having', 'do', 'does', \
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or',
 'because', 'as', 'until', 'while', 'of', \
            'at', 'by', 'for', 'with', 'about', 'against', 'between',
'into', 'through', 'during', 'before', 'after',\
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out',
'on', 'off', 'over', 'under', 'again', 'further',\
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'h
ow', 'all', 'any', 'both', 'each', 'few', 'more',\
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 's
o', 'than', 'too', 'very', \
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should',
"should've", 'now', 'd', 'll', 'm', 'o', 're', \
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't",
'didn', "didn't", 'doesn', "doesn't", 'hadn',\
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "is
n't", 'ma', 'mightn', "mightn't", 'mustn',\
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn',
 "shouldn't", 'wasn', "wasn't", 'weren', "weren't", \
            'won', "won't", 'wouldn', "wouldn't"])
```

In [22]:

```
# Combining all the above stundents
if not os.path.isfile('final.sqlite'):

    from tqdm import tqdm
    final_string=[]
    # tqdm is for printing the status bar
    for sentance in tqdm(final['Text'].values):
        sentance = re.sub(r"http\S+", "", sentance)
        sentance = BeautifulSoup(sentance, 'lxml').get_text()
        sentance = decontracted(sentance)
        sentance = re.sub("\S*\d\S*", "", sentance).strip()
        sentance = re.sub('[^A-Za-z]+', ' ', sentance)
        # https://gist.github.com/sebleier/554280
        sentance = ' '.join(e.lower() for e in sentance.split() if e.lo
wer() not in stopwords)
        final_string.append(sentance.strip())
```

```
        ##############---- storing the data into .sqlite file ------###
#####################
    final['CleanedText']=final_string #adding a column of CleanedText w
hich displays the data after pre-processing of the review
    final['CleanedText']=final['CleanedText'].str.decode("utf-8")
        # store final table into an SQlLite table for future.
    conn = sqlite3.connect('final.sqlite')
    c=conn.cursor()
    conn.text_factory = str
    final05.to_sql('Reviews', conn,  schema=None, if_exists='replace',
 \
                index=True, index_label=None, chunksize=None, dtype=No
ne)
    conn.close()
```

In [23]:
```
if os.path.isfile('final.sqlite'):
    conn = sqlite3.connect('final.sqlite')
    final1 = pd.read_sql_query(""" SELECT * FROM Reviews WHERE Score !=
 3 """, conn)
    conn.close()
else:
    print("Please the above cell")
```

In [24]:
```
final1.head(3)
final1['CleanedText'].head(5)
```

Out[24]:
```
0    witti littl book make son laugh loud recit car...
1    grew read sendak book watch realli rosi movi i...
2    fun way children learn month year learn poem t...
3    great littl book read nice rhythm well good re...
4    book poetri month year goe month cute littl po...
Name: CleanedText, dtype: object
```

[3.2] Preprocessing Review Summary

In [25]:
```
sorted_sample = final1.sort_values('Time', axis=0, ascending=True, inpl
```

```
ace=False, kind='quicksort', na_position='last')
sample_60000 = sorted_sample.iloc[0:100000]
final.shape
y = sample_60000['Score']
```

In [26]:
```
sample_60000.shape
```

Out[26]:
```
(100000, 12)
```

In [27]:
```
sample_60000["length"] = sample_60000['Text'].apply(len)
```

In [28]:
```
sample_60000.shape
```

Out[28]:
```
(100000, 13)
```

In [29]:
```
sample_60000.head(3)
```

Out[29]:

	index	Id	ProductId	UserId	ProfileName	HelpfulnessNumerato
0	138706	150524	0006641040	ACITT7DI6IDDL	shari zychinski	0
30	138683	150501	0006641040	AJ46FKXOVC7NR	Nicholas A Mesiano	2

	index	Id	ProductId	UserId	ProfileName	HelpfulnessNumerato
424	417839	451856	B00004CXX9	AIUWLEQ1ADEG5	Elizabeth Medina	0

In [30]:
```
sample_60000['Score'].value_counts()
```

Out[30]:
```
1    87729
0    12271
Name: Score, dtype: int64
```

In [31]:
```
from sklearn.model_selection import train_test_split

x_tr, x_ts, y_tr, y_ts = train_test_split(sample_60000, y, test_size=0.20) # this is random splitting
```

In [32]:
```
x_train, x_cv, y_train, y_cv = train_test_split(x_tr, y_tr, test_size=0.25) # this is random splitting
```

In [33]:
```
x_train.shape
```

Out[33]:
```
(60000, 13)
```

In [34]:
```
y_train.shape
```

Out[34]:
```
(60000,)
```

[4] Featurization

[4.1] BAG OF WORDS

[4.2] Bi-Grams and n-Grams.

In [97]:
```
#bi-gram, tri-gram and n-gram
from sklearn import preprocessing


#removing stop words like "not" should be avoided before building n-gra
ms
# count_vect = CountVectorizer(ngram_range=(1,2))
# please do read the CountVectorizer documentation http://scikit-learn.
org/stable/modules/generated/sklearn.feature_extraction.text.CountVecto
rizer.html

# you can choose these numebrs min_df=10, max_features=5000, of your ch
oice
count_vect = CountVectorizer(ngram_range=(1, 2),min_df=10) #in scikit-l
earn
x_tr_final_counts_bigram = count_vect.fit_transform(x_train['CleanedTex
t'].values)
x_cv_final_counts_bigram = count_vect.transform(x_cv['CleanedText'].val
ues)
x_ts_final_counts_bigram = count_vect.transform(x_ts['CleanedText'].val
ues)


print("the type of count vectorizer ",type(x_tr_final_counts_bigram))
print("the shape of out text BOW vectorizer ",x_tr_final_counts_bigram.
get_shape())
print("the number of unique words ", x_tr_final_counts_bigram.get_shape
()[1])

print("the type of count vectorizer ",type(x_cv_final_counts_bigram))
print("the shape of out text BOW vectorizer ",x_cv_final_counts_bigram.
get_shape())
print("the number of unique words ", x_cv_final_counts_bigram.get_shape
()[1])
```

```
print("the type of count vectorizer ",type(x_ts_final_counts_bigram))
print("the shape of out text BOW vectorizer ",x_ts_final_counts_bigram.
get_shape())
print("the number of unique words ", x_ts_final_counts_bigram.get_shape
()[1])


x_tr_final_counts_bigram = preprocessing.normalize(x_tr_final_counts_bi
gram)
x_cv_final_counts_bigram = preprocessing.normalize(x_cv_final_counts_bi
gram)
x_ts_final_counts_bigram = preprocessing.normalize(x_ts_final_counts_bi
gram)
```

```
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (60000, 34443)
the number of unique words  34443
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (20000, 34443)
the number of unique words  34443
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (20000, 34443)
the number of unique words  34443
```

[4.3] TF-IDF

In [98]:

```
tf_idf_vect = TfidfVectorizer(ngram_range=(1, 2),min_df=10)
x_tr_final_counts_tfidf = tf_idf_vect.fit_transform(x_train['CleanedTex
t'].values)
x_cv_final_counts_tfidf = tf_idf_vect.transform(x_cv['CleanedText'].val
ues)
x_ts_final_counts_tfidf = tf_idf_vect.transform(x_ts['CleanedText'].val
ues)


print("the type of count vectorizer ",type(x_tr_final_counts_tfidf))
print("the shape of out text TFIDF vectorizer ",x_tr_final_counts_tfidf
.get_shape())
```

```
print("the number of unique words including both unigrams and bigrams "
, x_tr_final_counts_tfidf.get_shape()[1])

print("the type of count vectorizer ",type(x_cv_final_counts_tfidf))
print("the shape of out text TFIDF vectorizer ",x_cv_final_counts_tfidf
.get_shape())
print("the number of unique words including both unigrams and bigrams "
, x_cv_final_counts_tfidf.get_shape()[1])

print("the type of count vectorizer ",type(x_ts_final_counts_tfidf))
print("the shape of out text TFIDF vectorizer ",x_ts_final_counts_tfidf
.get_shape())
print("the number of unique words including both unigrams and bigrams "
, x_ts_final_counts_tfidf.get_shape()[1])


x_tr_final_counts_tfidf = preprocessing.normalize(x_tr_final_counts_tfi
df)
x_cv_final_counts_tfidf = preprocessing.normalize(x_cv_final_counts_tfi
df)
x_ts_final_counts_tfidf = preprocessing.normalize(x_ts_final_counts_tfi
df)
```

```
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (60000, 34443)
the number of unique words including both unigrams and bigrams  34443
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (20000, 34443)
the number of unique words including both unigrams and bigrams  34443
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (20000, 34443)
the number of unique words including both unigrams and bigrams  34443
```

[4.4] Word2Vec

In [99]:
```
# Train your own Word2Vec model using your own text corpus
i=0
list_of_sentance_train=[]
```

```
for sentance in x_train['CleanedText'].values:
    list_of_sentance_train.append(sentance.split())
```

In [100]:
```
# Train your own Word2Vec model using your own text corpus
i=0
list_of_sentance_cv=[]
for sentance in x_cv['CleanedText'].values:
    list_of_sentance_cv.append(sentance.split())
```

In [101]:
```
# Train your own Word2Vec model using your own text corpus
i=0
list_of_sentance_ts=[]
for sentance in x_ts['CleanedText'].values:
    list_of_sentance_ts.append(sentance.split())
```

In [102]:
```
print(len(list_of_sentance_train))
print(len(list_of_sentance_cv))
print(len(list_of_sentance_ts))
```

```
60000
20000
20000
```

In [103]:
```
def convertByteStringtoString(sentlist):
    for x in sentlist:
        for i in range(len(x)):
            x[i] = x[i]

    return sentlist
```

In [104]:
```
list_of_sentance_train = convertByteStringtoString(list_of_sentance_tra
in)
list_of_sentance_cv = convertByteStringtoString(list_of_sentance_cv)
list_of_sentance_ts = convertByteStringtoString(list_of_sentance_ts)
```

In [105]:
```
# min_count = 5 considers only words that occured atleast 5 times
w2v_model=Word2Vec(list_of_sentance_train,min_count=5,size=50, workers=
```

```
4)
```

In [106]:
```
w2v_words = list(w2v_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  10040
sample words  ['tea', 'parti', 'theme', 'babi', 'shower', 'son', 'wif
e', 'purchas', 'numi', 'bamboo', 'gift', 'set', 'clear', 'pot', 'flowe
r', 'describ', 'put', 'teapot', 'convers', 'great', 'open', 'make', 'pa
rt', 'event', 'know', 'guest', 'talk', 'next', 'day', 'chickpea', 'bea
n', 'excel', 'sourc', 'mani', 'miner', 'protein', 'two', 'pack', 'orde
r', 'get', 'free', 'ship', 'care', 'select', 'fresh', 'smell', 'use',
'most', 'soup', 'automat']
```

[4.4.1] Converting text into vectors using Avg W2V, TFIDF-W2V

[4.4.1.1] Avg W2v

In [107]:
```
# average Word2Vec
# compute average word2vec for each review.

train_avgw2v = []; # the avg-w2v for each sentence/review is stored in
 this list
for sent in tqdm(list_of_sentance_train): # for each review/sentence
    sent_vec = np.zeros(50) # as word vectors are of zero length 50, yo
u might need to change this to 300 if you use google's w2v
    cnt_words =0; # num of words with a valid vector in the sentence/re
view
    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
    train_avgw2v.append(sent_vec)
```

```
print(len(train_avgw2v))
print(len(train_avgw2v[0]))
```

```
100%|████████████████████████████████| 60000/60000 [01:49<00:00, 54
6.04it/s]
```

```
60000
50
```

In [108]:

```
cv_avgw2v = []; # the avg-w2v for each sentence/review is stored in thi
s list
for sent in tqdm(list_of_sentance_cv): # for each review/sentence
    sent_vec = np.zeros(50) # as word vectors are of zero length 50, yo
u might need to change this to 300 if you use google's w2v
    cnt_words =0; # num of words with a valid vector in the sentence/re
view
    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
    cv_avgw2v.append(sent_vec)
print(len(cv_avgw2v))
print(len(cv_avgw2v[0]))
```

```
100%|████████████████████████████████| 20000/20000 [00:36<00:00, 54
1.23it/s]
```

```
20000
50
```

In [109]:

```
test_avgw2v = []; # the avg-w2v for each sentence/review is stored in t
his list
for sent in tqdm(list_of_sentance_ts): # for each review/sentence
    sent_vec = np.zeros(50) # as word vectors are of zero length 50, yo
u might need to change this to 300 if you use google's w2v
    cnt_words =0; # num of words with a valid vector in the sentence/re
view
```

```
    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
    test_avgw2v.append(sent_vec)
print(len(test_avgw2v))
print(len(test_avgw2v[0]))
```

```
100%|██████████████████████████████████| 20000/20000 [00:36<00:00, 54
0.56it/s]
```

```
20000
50
```

In [110]:
```
train_avgw2v = preprocessing.normalize(train_avgw2v)
cv_avgw2v = preprocessing.normalize(cv_avgw2v)
test_avgw2v = preprocessing.normalize(test_avgw2v)
```

In [111]:
```
train_avgw2v = np.array(train_avgw2v)
cv_avgw2v = np.array(cv_avgw2v)
test_avgw2v = np.array(test_avgw2v)
```

In [112]:
```
np.isnan(train_avgw2v).any()
```

Out[112]: False

In [113]:
```
np.isnan(cv_avgw2v).any()
```

Out[113]: False

In [114]:
```
np.isnan(test_avgw2v).any()
```

Out[114]: False

[4.4.1.2] TFIDF weighted W2v

In [115]:
```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
model = TfidfVectorizer()
x_tr_final_counts_TFIDF_w2v = model.fit_transform(x_train['CleanedText'
].values)
x_cv_final_counts_TFIDF_w2v = model.transform(x_cv['CleanedText'].value
s)
x_ts_final_counts_TFIDF_w2v = model.transform(x_ts['CleanedText'].value
s)

# we are converting a dictionary with word as a key, and the idf as a v
alue
dictionary = dict(zip(model.get_feature_names(), list(model.idf_)))
```

In [116]:
```
# TF-IDF weighted Word2Vec Train Data
tfidf_feat = model.get_feature_names() # tfidf words/col-names
# final_tf_idf is the sparse matrix with row= sentence, col=word and ce
ll_val = tfidf

tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is st
ored in this list
row=0;
for sent in tqdm(list_of_sentance_train): # 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/r
eview
    for word in sent: # for each word in a review/sentence
        if word in w2v_words and word in tfidf_feat:
            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
```

```
100%|████████████████████████████████| 60000/60000 [20:02<00:00, 49.88it/s]
```

In [117]:

```
# TF-IDF weighted Word2Vec cv Data
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 = tfidf

tfidf_sent_vectors_cv = []; # the tfidf-w2v for each sentence/review is stored in this list
row=0;
for sent in tqdm(list_of_sentance_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 and word in tfidf_feat:
            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_cv.append(sent_vec)
    row += 1
```

```
100%|████████████████████████████████| 20000/20000 [06:53<00:00, 48.36it/s]
```

In [118]:

```
# TF-IDF weighted Word2Vec test Data
tfidf_feat = model.get_feature_names() # tfidf words/col-names
```

```
# final_tf_idf is the sparse matrix with row= sentence, col=word and ce
ll_val = tfidf

tfidf_sent_vectors_ts = []; # the tfidf-w2v for each sentence/review is
 stored in this list
row=0;
for sent in tqdm(list_of_sentance_ts): # 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/r
eview
    for word in sent: # for each word in a review/sentence
        if word in w2v_words and word in tfidf_feat:
            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_ts.append(sent_vec)
    row += 1
```

```
100%|██████████████████████████████████| 20000/20000 [06:39<00:00, 5
0.06it/s]
```

In [119]:
```
tfidf_sent_vectors = preprocessing.normalize(tfidf_sent_vectors)
tfidf_sent_vectors_cv = preprocessing.normalize(tfidf_sent_vectors_cv)
tfidf_sent_vectors_ts = preprocessing.normalize(tfidf_sent_vectors_ts)
```

In [120]:
```
tfidf_sent_vectors = np.array(tfidf_sent_vectors)
tfidf_sent_vectors_cv = np.array(tfidf_sent_vectors_cv)
tfidf_sent_vectors_ts = np.array(tfidf_sent_vectors_ts)
```

In [121]:
```
np.isnan(tfidf_sent_vectors).any()
```

Out[121]: False

In [122]:
```
np.isnan(tfidf_sent_vectors_cv).any()
```

Out[122]: False

In [123]:
```
np.isnan(tfidf_sent_vectors_ts).any()
```

Out[123]: False

RBF

In [35]:
```
sorted_sample1 = final1.sort_values('Time', axis=0, ascending=True, inp
lace=False, kind='quicksort', na_position='last')
sample_600001 = sorted_sample1.iloc[0:20000]

y1 = sample_600001['Score']
```

In [36]:
```
sample_600001.shape
```

Out[36]: (20000, 12)

In [37]:
```
sample_600001["length"] = sample_600001['Text'].apply(len)
```

In [38]:
```
sample_600001.shape
```

Out[38]: (20000, 13)

In [39]:
```
sample_600001.head(3)
```

Out[39]:

	index	Id	ProductId	UserId	ProfileName	HelpfulnessNumerato

	index	Id	ProductId	UserId	ProfileName	HelpfulnessNumerato
0	138706	150524	0006641040	ACITT7DI6IDDL	shari zychinski	0
30	138683	150501	0006641040	AJ46FKXOVC7NR	Nicholas A Mesiano	2
424	417839	451856	B00004CXX9	AIUWLEQ1ADEG5	Elizabeth Medina	0

In [40]:
```
sample_600001['Score'].value_counts()
```

Out[40]:
```
1    17826
0     2174
Name: Score, dtype: int64
```

In [41]:
```
from sklearn.model_selection import train_test_split

x_tr_rbf, x_ts_rbf, y_tr_rbf, y_ts_rbf = train_test_split(sample_600001
, y1, test_size=0.20) # this is random splitting
```

In [42]:
```
x_train_rbf, x_cv_rbf, y_train_rbf, y_cv_rbf = train_test_split(x_tr_rb
f, y_tr_rbf, test_size=0.25) # this is random splitting
```

In [43]:
```
x_train_rbf.shape
```

Out[43]: (12000, 13)

In [44]:
```
y_train_rbf.shape
```

Out[44]: (12000,)

In [45]:
```
x_ts_rbf.shape
```

Out[45]: (4000, 13)

In [46]:
```
y_ts_rbf.shape
```

Out[46]: (4000,)

Bi-Grams and n-Grams for rbf

In [47]:
```
#bi-gram, tri-gram and n-gram
from sklearn import preprocessing

#removing stop words like "not" should be avoided before building n-gra
ms
# count_vect = CountVectorizer(ngram_range=(1,2))
# please do read the CountVectorizer documentation http://scikit-learn.
org/stable/modules/generated/sklearn.feature_extraction.text.CountVecto
rizer.html

# you can choose these numebrs min_df=10, max_features=5000, of your ch
oice
count_vect = CountVectorizer(ngram_range=(1, 2),min_df=10,max_features
= 500) #in scikit-learn
x_tr_final_counts_bigram_rbf = count_vect.fit_transform(x_train_rbf['Cl
eanedText'].values)
x_cv_final_counts_bigram_rbf = count_vect.transform(x_cv_rbf['CleanedTe
xt'].values)
x_ts_final_counts_bigram_rbf = count_vect.transform(x_ts_rbf['CleanedTe
```

```
xt'].values)


print("the type of count vectorizer ",type(x_tr_final_counts_bigram_rbf
))
print("the shape of out text BOW vectorizer ",x_tr_final_counts_bigram_
rbf.get_shape())
print("the number of unique words ", x_tr_final_counts_bigram_rbf.get_s
hape()[1])

print("the type of count vectorizer ",type(x_cv_final_counts_bigram_rbf
))
print("the shape of out text BOW vectorizer ",x_cv_final_counts_bigram_
rbf.get_shape())
print("the number of unique words ", x_cv_final_counts_bigram_rbf.get_s
hape()[1])

print("the type of count vectorizer ",type(x_ts_final_counts_bigram_rbf
))
print("the shape of out text BOW vectorizer ",x_ts_final_counts_bigram_
rbf.get_shape())
print("the number of unique words ", x_ts_final_counts_bigram_rbf.get_s
hape()[1])


x_tr_final_counts_bigram_rbf = preprocessing.normalize(x_tr_final_count
s_bigram_rbf)
x_cv_final_counts_bigram_rbf = preprocessing.normalize(x_cv_final_count
s_bigram_rbf)
x_ts_final_counts_bigram_rbf = preprocessing.normalize(x_ts_final_count
s_bigram_rbf)
```

```
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (12000, 500)
the number of unique words  500
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (4000, 500)
the number of unique words  500
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
```

```
the shape of out text BOW vectorizer  (4000, 500)
the number of unique words  500
```

tf_idf for rbf

In [48]:

```
tf_idf_vect = TfidfVectorizer(ngram_range=(1, 2),min_df=10,max_features
 = 500)
x_tr_final_counts_tfidf_rbf = tf_idf_vect.fit_transform(x_train_rbf['Cl
eanedText'].values)
x_cv_final_counts_tfidf_rbf = tf_idf_vect.transform(x_cv_rbf['CleanedTe
xt'].values)
x_ts_final_counts_tfidf_rbf = tf_idf_vect.transform(x_ts_rbf['CleanedTe
xt'].values)

x_tr_final_counts_tfidf_rbf = preprocessing.normalize(x_tr_final_counts
_tfidf_rbf)
x_cv_final_counts_tfidf_rbf = preprocessing.normalize(x_cv_final_counts
_tfidf_rbf)
x_ts_final_counts_tfidf_rbf = preprocessing.normalize(x_ts_final_counts
_tfidf_rbf)


print("the type of count vectorizer ",type(x_tr_final_counts_tfidf_rbf
))
print("the shape of out text TFIDF vectorizer ",x_tr_final_counts_tfidf
_rbf.get_shape())
print("the number of unique words including both unigrams and bigrams "
, x_tr_final_counts_tfidf_rbf.get_shape()[1])

print("the type of count vectorizer ",type(x_cv_final_counts_tfidf_rbf
))
print("the shape of out text TFIDF vectorizer ",x_cv_final_counts_tfidf
_rbf.get_shape())
print("the number of unique words including both unigrams and bigrams "
, x_cv_final_counts_tfidf_rbf.get_shape()[1])

print("the type of count vectorizer ",type(x_ts_final_counts_tfidf_rbf
```

```
))
print("the shape of out text TFIDF vectorizer ",x_ts_final_counts_tfidf
_rbf.get_shape())
print("the number of unique words including both unigrams and bigrams "
, x_ts_final_counts_tfidf_rbf.get_shape()[1])
```

```
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (12000, 500)
the number of unique words including both unigrams and bigrams  500
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (4000, 500)
the number of unique words including both unigrams and bigrams  500
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer  (4000, 500)
the number of unique words including both unigrams and bigrams  500
```

Word2Vec Train Data

In [49]:
```
# Train your own Word2Vec model using your own text corpus
i=0
list_of_sentance_rbf=[]
for sentance in x_train_rbf['CleanedText'].values:
    list_of_sentance_rbf.append(sentance.split())
```

In [50]:
```
# Train your own Word2Vec model using your own text corpus
i=0
list_of_sentance_cv_rbf=[]
for sentance in x_cv_rbf['CleanedText'].values:
    list_of_sentance_cv_rbf.append(sentance.split())
```

In [51]:
```
# Train your own Word2Vec model using your own text corpus
i=0
list_of_sentance_ts_rbf=[]
for sentance in x_ts_rbf['CleanedText'].values:
    list_of_sentance_ts_rbf.append(sentance.split())
```

In [52]:
```
print(len(list_of_sentance_rbf))
print(len(list_of_sentance_cv_rbf))
print(len(list_of_sentance_ts_rbf))
```

```
12000
4000
4000
```

In [53]:
```
def convertByteStringtoString(sentlist):
    for x in sentlist:
        for i in range(len(x)):
            x[i] = x[i]

    return sentlist
```

In [54]:
```
list_of_sentance_rbf = convertByteStringtoString(list_of_sentance_rbf)
list_of_sentance_cv_rbf = convertByteStringtoString(list_of_sentance_cv
_rbf)
list_of_sentance_ts_rbf = convertByteStringtoString(list_of_sentance_ts
_rbf)
```

In [55]:
```
# min_count = 5 considers only words that occured atleast 5 times
w2v_model_rbf=Word2Vec(list_of_sentance_rbf,min_count=5,size=500, worke
rs=4)
```

In [56]:
```
w2v_words_rbf = list(w2v_model_rbf.wv.vocab)
print("number of words that occured minimum 5 times ",len(w2v_words_rbf
))
print("sample words ", w2v_words_rbf[0:500])
```

```
number of words that occured minimum 5 times  4972
sample words  ['one', 'review', 'said', 'care', 'dont', 'eat', 'entir',
'packag', 'well', 'didnt', 'work', 'incred', 'order', 'case', 'last',
'week', 'offic', 'find', 'pretzel', 'better', 'real', 'delici', 'orga
n', 'full', 'flavor', 'hit', 'hous', 'plump', 'rice', 'fat', 'carrot',
'tasti', 'chicken', 'great', 'soup', 'titl', 'pretti', 'much', 'say',
'reserv', 'star', 'consid', 'best', 'want', 'cereal', 'differ', 'ive',
```

```
'year', 'definit', 'like', 'usual', 'crispi', 'substanti', 'air', 'nic
e', 'though', 'strong', 'cocoa', 'doesnt', 'get', 'soggi', 'first', 'tw
o', 'minut', 'milk', 'drink', 'product', 'pour', 'anoth', 'talk', 'empt
i', 'calori', 'ill', 'generous', 'assum', 'particular', 'familiar', 're
ad', 'compar', 'nutrit', 'label', 'high', 'qualiti', 'also', 'would',
'crisp', 'reveal', 'almost', 'ident', 'valu', 'perhap', 'never', 'clai
m', 'fulli', 'balanc', 'meal', 'neither', 'made', 'ingredi', 'none', 'a
rtifici', 'vitamin', 'miner', 'ad', 'groceri', 'store', 'make', 'look',
'design', 'use', 'part', 'diet', 'way', 'plain', 'good', 'buy', 'seve
r', 'time', 'per', 'breakfast', 'connect', 'compani', 'love', 'mani',
'theyd', 'add', 'line', 'larg', 'bulk', 'bag', 'even', 'happier', 'hel
p', 'mild', 'breath', 'problem', 'surpris', 'haribo', 'allow', 'name',
'noth', 'tradit', 'fare', 'golden', 'bear', 'someth', 'expect', 'see',
'wont', 'grandkid', 'live', 'learn', 'stuff', 'wild', 'ride', 'pepper',
'nitrit', 'msg', 'natur', 'healthi', 'still', 'beef', 'low', 'serv', 'p
rotein', 'watch', 'weight', 'welcom', 'addit', 'essenti', 'slice', 'ste
ak', 'averag', 'piec', 'inch', 'squar', 'thick', 'keep', 'mind', 'jerk
i', 'thus', 'lover', 'may', 'put', 'tender', 'meat', 'your', 'tough',
'consist', 'tire', 'els', 'chewi', 'contain', 'gristl', 'break', 'compl
et', 'chew', 'inconveni', 'minor', 'enough', 'give', 'five', 'base', 'o
veral', 'tast', 'perfect', 'overpow', 'mmmmmm', 'yummi', 'fall', 'tun
a', 'tri', 'smoke', 'grandmoth', 'wonder', 'box', 'send', 'mother', 'si
nc', 'havent', 'seen', 'avail', 'recommend', 'take', 'littl', 'bit', 'o
liv', 'oil', 'vinegar', 'mix', 'cucumb', 'chees', 'green', 'onion', 'da
sh', 'salt', 'that', 'snack', 'happi', 'studi', 'night', 'wise', 'dip',
'north', 'unfortun', 'florida', 'couldnt', 'amazon', 'continu', 'recie
v', 'today', 'quicker', 'item', 'set', 'realli', 'enjoy', 'festiv', 'th
ai', 'food', 'recent', 'adopt', 'total', 'asian', 'cook', 'health', 're
ason', 'third', 'lost', 'pound', 'pain', 'gone', 'benefit', 'satisfi',
'crave', 'spici', 'sweet', 'anymor', 'shot', 'hard', 'area', 'limit',
'access', 'wholesom', 'thank', 'offer', 'subtl', 'lemongrass', 'alot',
'cheaper', 'cost', 'cup', 'day', 'sweetner', 'everyth', 'purchas', 'pro
cess', 'ultra', 'temperatur', 'main', 'europ', 'fact', 'franc', 'isnt',
'long', 'without', 'refriger', 'slight', 'kid', 'least', 'cant', 'smoot
h', 'american', 'stori', 'husband', 'coffe', 'robust', 'bitter', 'remin
d', 'expresso', 'stove', 'machin', 'could', 'everyday', 'agre', 'provi
d', 'nutti', 'interv', 'pod', 'system', 'quick', 'easi', 'fresh', 'ho
t', 'brew', 'everi', 'treat', 'fantast', 'abl', 'administ', 'type', 'pi
ll', 'seem', 'notic', 'crunch', 'human', 'grade', 'cat', 'antibiot', 'k
```

```
ind', 'famous', 'red', 'bean', 'recip', 'scratch', 'yet', 'beat', 'zata
rain', 'season', 'simpl', 'famili', 'absolut', 'favorit', 'friend', 'co
me', 'swear', 'ever', 'grandma', 'mom', 'etc', 'away', 'truli', 'typi
c', 'turkey', 'sausag', 'imposs', 'bet', 'fun', 'receiv', 'oversea', 'i
raq', 'impress', 'excit', 'shipment', 'invit', 'share', 'soooo', 'sid
e', 'wasabi', 'tube', 'comparison', 'japanes', 'sushi', 'bar', 'exact',
'pleas', 'regular', 'basi', 'ten', 'can', 'three', 'big', 'bigger', 'fr
uit', 'found', 'dessert', 'creami', 'alway', 'honey', 'crystal', 'whol
e', 'wish', 'came', 'larger', 'size', 'hold', 'raw', 'pure', 'heaven',
'school', 'teacher', 'allergi', 'diabet', 'need', 'fast', 'meet', 'diet
ari', 'erewhon', 'twice', 'grain', 'banana', 'fructos', 'met', 'rais',
'child', 'closest', 'lose', 'altern', 'potato', 'chip', 'reduc', 'dail
i', 'intak', 'wasa', 'crispbread', 'favor', 'consum', 'report', 'deci
d', 'textur', 'mouth', 'feel', 'cracker', 'unlik', 'brand', 'sourdoug
h', 'actual', 'decent', 'hint', 'tang', 'rye', 'vari', 'info', 'cholest
erol', 'sodium', 'carbohydr', 'fiber', 'sugar', 'number', 'australian',
'licoric', 'short', 'rather', 'thin', 'weak', 'pasti', 'linger', 'after
tast', 'posit', 'possibl', 'lot', 'variabl', 'among', 'batch', 'simila
r', 'wow', 'weve', 'macaroni', 'anni', 'butter', 'sauc', 'past', 'foi
l', 'creativ', 'tip', 'boil', 'plenti', 'water', 'requir', 'minimum',
'drain']
```

In [57]:
```
# Converting text into vectors using Avg W2V, TFIDF-W2V
```

In [58]:
```
 # Avg W2v rbf
```

In [59]:
```
# average Word2Vec
# compute average word2vec for each review.

train_avgw2v_rbf = []; # the avg-w2v for each sentence/review is stored
 in this list
for sent in tqdm(list_of_sentance_rbf): # for each review/sentence
    sent_vec = np.zeros(500) # as word vectors are of zero length 50, y
ou might need to change this to 300 if you use google's w2v
    cnt_words =0; # num of words with a valid vector in the sentence/re
view
    for word in sent: # for each word in a review/sentence
        if word in w2v_words_rbf:
```

```
            vec = w2v_model_rbf.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    train_avgw2v_rbf.append(sent_vec)
print(len(train_avgw2v_rbf))
print(len(train_avgw2v_rbf[0]))
```

```
100%|██████████████████████████████████| 12000/12000 [00:17<00:00, 68
0.31it/s]
```

```
12000
500
```

In [60]:

```
cv_avgw2v_rbf = []; # the avg-w2v for each sentence/review is stored in
 this list
for sent in tqdm(list_of_sentance_cv_rbf): # for each review/sentence
    sent_vec = np.zeros(500) # as word vectors are of zero length 50, y
ou might need to change this to 300 if you use google's w2v
    cnt_words =0; # num of words with a valid vector in the sentence/re
view
    for word in sent: # for each word in a review/sentence
        if word in w2v_words_rbf:
            vec = w2v_model_rbf.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    cv_avgw2v_rbf.append(sent_vec)
print(len(cv_avgw2v_rbf))
print(len(cv_avgw2v_rbf[0]))
```

```
100%|██████████████████████████████████| 4000/4000 [00:05<00:00, 68
1.46it/s]
```

```
4000
500
```

In [61]:

```
test_avgw2v_rbf = []; # the avg-w2v for each sentence/review is stored
```

```
 in this list
for sent in tqdm(list_of_sentance_ts_rbf): # for each review/sentence
    sent_vec = np.zeros(500) # as word vectors are of zero length 50, y
ou might need to change this to 300 if you use google's w2v
    cnt_words =0; # num of words with a valid vector in the sentence/re
view
    for word in sent: # for each word in a review/sentence
        if word in w2v_words_rbf:
            vec = w2v_model_rbf.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    test_avgw2v_rbf.append(sent_vec)
print(len(test_avgw2v_rbf))
print(len(test_avgw2v_rbf[0]))
```

```
100%|██████████████████████████████████| 4000/4000 [00:05<00:00, 67
8.59it/s]
```

```
4000
500
```

In [62]:
```
train_avgw2v_rbf = preprocessing.normalize(train_avgw2v_rbf)
cv_avgw2v_rbf = preprocessing.normalize(cv_avgw2v_rbf)
test_avgw2v_rbf = preprocessing.normalize(test_avgw2v_rbf)
```

In [63]:
```
train_avgw2v_rbf = np.array(train_avgw2v_rbf)
cv_avgw2v_rbf = np.array(cv_avgw2v_rbf)
test_avgw2v_rbf = np.array(test_avgw2v_rbf)
```

In [64]:
```
np.isnan(train_avgw2v_rbf).any()
```

Out[64]: False

In [65]:
```
np.isnan(cv_avgw2v_rbf).any()
```

Out[65]: False

In [66]:
```
np.isnan(test_avgw2v_rbf).any()
```

Out[66]: False

In [67]:
```
# TFIDF weighted W2v for rbf
```

In [68]:
```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
model = TfidfVectorizer(min_df=10,max_features = 500)
x_tr_final_counts_TFIDF_w2v_rbf = model.fit_transform(x_train_rbf['Clea
nedText'].values)
x_cv_final_counts_TFIDF_w2v_rbf = model.transform(x_cv_rbf['CleanedTex
t'].values)
x_ts_final_counts_TFIDF_w2v_rbf = model.transform(x_ts_rbf['CleanedTex
t'].values)

# we are converting a dictionary with word as a key, and the idf as a v
alue
dictionary = dict(zip(model.get_feature_names(), list(model.idf_)))
```

In [69]:
```
# TF-IDF weighted Word2Vec Train Data
tfidf_feat = model.get_feature_names() # tfidf words/col-names
# final_tf_idf is the sparse matrix with row= sentence, col=word and ce
ll_val = tfidf

tfidf_sent_vectors_rbf = []; # the tfidf-w2v for each sentence/review i
s stored in this list
row=0;
for sent in tqdm(list_of_sentance_rbf): # for each review/sentence
    sent_vec = np.zeros(500) # as word vectors are of zero length
    weight_sum =0; # num of words with a valid vector in the sentence/r
eview
    for word in sent: # for each word in a review/sentence
        if word in w2v_words_rbf and word in tfidf_feat:
            vec = w2v_model_rbf.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_rbf.append(sent_vec)
    row += 1
```

```
100%|██████████████████████████████████| 12000/12000 [00:23<00:00, 51
8.19it/s]
```

In [70]:

```
# TF-IDF weighted Word2Vec cv Data
tfidf_feat = model.get_feature_names() # tfidf words/col-names
# final_tf_idf is the sparse matrix with row= sentence, col=word and ce
ll_val = tfidf

tfidf_sent_vectors_cv_rbf = []; # the tfidf-w2v for each sentence/revie
w is stored in this list
row=0;
for sent in tqdm(list_of_sentance_cv_rbf): # for each review/sentence
    sent_vec = np.zeros(500) # as word vectors are of zero length
    weight_sum =0; # num of words with a valid vector in the sentence/r
eview
    for word in sent: # for each word in a review/sentence
        if word in w2v_words_rbf and word in tfidf_feat:
            vec = w2v_model_rbf.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_cv_rbf.append(sent_vec)
    row += 1
```

```
100%|██████████████████████████████████| 4000/4000 [00:08<00:00, 49

```

```
9.41it/s]
```

In [71]:
```
# TF-IDF weighted Word2Vec test Data
tfidf_feat = model.get_feature_names() # tfidf words/col-names
# final_tf_idf is the sparse matrix with row= sentence, col=word and ce
ll_val = tfidf

tfidf_sent_vectors_ts_rbf = []; # the tfidf-w2v for each sentence/revie
w is stored in this list
row=0;
for sent in tqdm(list_of_sentance_ts_rbf): # for each review/sentence
    sent_vec = np.zeros(500) # as word vectors are of zero length
    weight_sum =0; # num of words with a valid vector in the sentence/r
eview
    for word in sent: # for each word in a review/sentence
        if word in w2v_words_rbf and word in tfidf_feat:
            vec = w2v_model_rbf.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_ts_rbf.append(sent_vec)
    row += 1
```

```
100%|████████████████████████████████████| 4000/4000 [00:07<00:00, 52
2.85it/s]
```

In [72]:
```
tfidf_sent_vectors_rbf = preprocessing.normalize(tfidf_sent_vectors_rbf
)
tfidf_sent_vectors_cv_rbf = preprocessing.normalize(tfidf_sent_vectors_
cv_rbf)
tfidf_sent_vectors_ts_rbf = preprocessing.normalize(tfidf_sent_vectors_
ts_rbf)
```

In [73]:
```
tfidf_sent_vectors_rbf = np.array(tfidf_sent_vectors_rbf)
tfidf_sent_vectors_cv_rbf = np.array(tfidf_sent_vectors_cv_rbf)
tfidf_sent_vectors_ts_rbf = np.array(tfidf_sent_vectors_ts_rbf)
```

In [74]:
```
np.isnan(tfidf_sent_vectors_rbf).any()
```

Out[74]: False

In [75]:
```
np.isnan(tfidf_sent_vectors_ts_rbf).any()
```

Out[75]: False

In [76]:
```
np.isnan(tfidf_sent_vectors_cv_rbf).any()
```

Out[76]: False

[5] Assignment 7: SVM

1. **Apply SVM on these feature sets**

   - SET 1:Review text, preprocessed one converted into vectors using (BOW)
   - SET 2:Review text, preprocessed one converted into vectors using (TFIDF)
   - SET 3:Review text, preprocessed one converted into vectors using (AVG W2v)
   - SET 4:Review text, preprocessed one converted into vectors using (TFIDF W2v)

2. **Procedure**

   - You need to work with 2 versions of SVM
     - Linear kernel
     - RBF kernel
   - When you are working with linear kernel, use SGDClassifier' with hinge loss because it is computationally less expensive.

- When you are working with 'SGDClassifier' with hinge loss and trying to find the AUC score, you would have to use CalibratedClassifierCV
- Similarly, like kdtree of knn, when you are working with RBF kernel it's better to reduce the number of dimensions. You can put min_df = 10, max_features = 500 and consider a sample size of 40k points.

3. **Hyper paramter tuning (find best alpha in range [10^-4 to 10^4], and the best penalty among 'l1', 'l2')**

   - Find the best hyper parameter which will give the maximum AUC value
   - Find the best hyper paramter using k-fold cross validation or simple cross validation data
   - Use gridsearch cv or randomsearch cv or you can also write your own for loops to do this task of hyperparameter tuning

4. **Feature importance**

   - When you are working on the linear kernel with BOW or TFIDF please print the top 10 best features for each of the positive and negative classes.

5. **Feature engineering**

   - To increase the performance of your model, you can also experiment with with feature engineering like :
     - Taking length of reviews as another feature.
     - Considering some features from review summary as well.

6. **Representation of results**

   - You need to plot the performance of model both on train data and cross validation data for each hyper parameter, like shown in the figure.
      Once after you found the best hyper parameter, you need to train your model with it, and find the AUC on test data and plot the ROC curve on both train and test.
     

Along with plotting ROC curve, you need to print the confusion matrix with predicted and original labels of test data points. Please visualize your confusion matrices using seaborn heatmaps.

7. **Conclusion**

- You need to summarize the results at the end of the notebook, summarize it in the table format. To print out a table please refer to this prettytable library link

Note: Data Leakage

1. There will be an issue of data-leakage if you vectorize the entire data and then split it into train/cv/test.
2. To avoid the issue of data-leakag, make sure to split your data first and then vectorize it.
3. While vectorizing your data, apply the method fit_transform() on you train data, and apply the method transform() on cv/test data.
4. For more details please go through this link.

Applying SVM

[5.1] Linear SVM

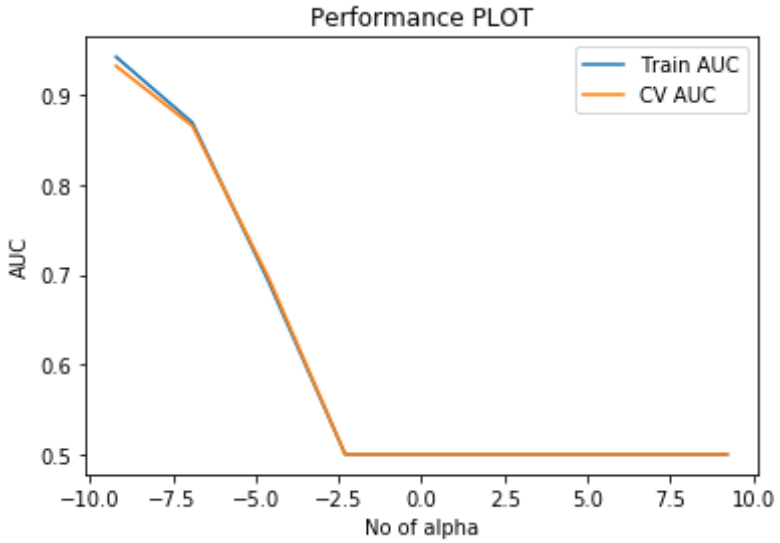
[5.1.1] Applying Linear SVM on BOW, SET 1

In [142]:
```
# Please write all the code with proper documentation
# Linear kernel svm for L1 penalty
from sklearn.calibration import CalibratedClassifierCV
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_auc_score
```

```
alpha_values = np.arange(10)

acc = np.empty(len(alpha_values))
error = np.empty(len(alpha_values))
C = np.array([0.0001,0.001,0.01,0.1,1,10,100,500,1000,10000])

cv_auc = []
train_auc = []
i = 0
for alpha in C:
    clf = SGDClassifier(loss='hinge',penalty='l1',alpha = alpha,class_w
eight='balanced')
    clf.fit(x_tr_final_counts_bigram, y_train)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(x_tr_final_counts_bigram, y_train)
    y_cv_pred = sig_clf.predict_proba(x_cv_final_counts_bigram)[:,1]
    y_train_pred =  sig_clf.predict_proba(x_tr_final_counts_bigram)[:,1
]

    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

d = max(cv_auc)

i = np.where(cv_auc == d)

i = i[0][0]
best_alpha = float(C[i])
print("Best alpha is:-",best_alpha)


C = np.log(C)


plt.plot(C, train_auc, label='Train AUC')
plt.plot(C, cv_auc, label='CV AUC')
plt.legend()
plt.xlabel("No of alpha")
```

```
plt.ylabel("AUC")
plt.title("Performance PLOT")
plt.show()
```

```
Best alpha is:- 0.0001
```

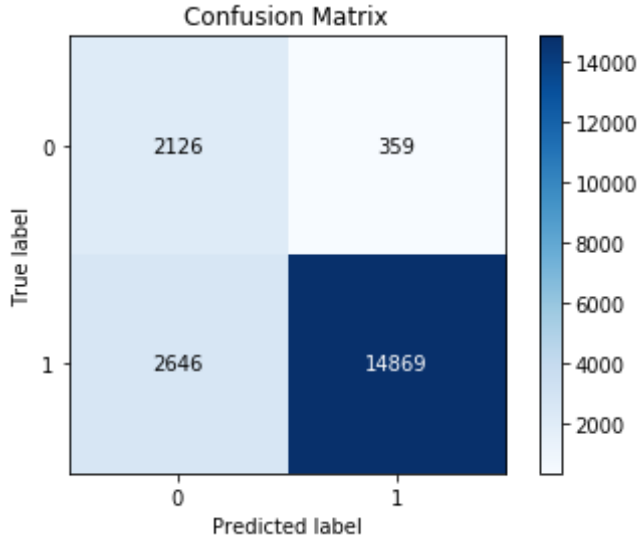


In [143]:
```
# SGDClassifier with best best "alpha" for l1 penalty of bow
model = SGDClassifier(loss='hinge',penalty='l1',alpha = best_alpha,clas
s_weight='balanced')
model.fit(x_tr_final_counts_bigram,y_train)
sig_clf = CalibratedClassifierCV(model, method="sigmoid")
sig_clf.fit(x_tr_final_counts_bigram,y_train)
#pred = model.predict_proba(x_ts_final_counts_bigram)
pred=model.predict(x_ts_final_counts_bigram)
    # evaluate CV AUC
auc_score_bowT_l1 = roc_auc_score(y_true=np.array(y_ts), y_score=sig_cl
f.predict_proba(x_ts_final_counts_bigram)[:,1])*100
auc_score_bowT_lambda_l1 = best_alpha
print('\nThe AUCScore of the SGDClassifier of best alpha = %f is %f%%'
% (best_alpha, auc_score_bowT_l1))
```

```
The AUCScore of the SGDClassifier of best alpha = 0.000100 is 93.24374
0%
```

In [144]:
```
import scikitplot.metrics as skplt
skplt.plot_confusion_matrix(y_ts ,pred)
```

Out[144]: <matplotlib.axes._subplots.AxesSubplot at 0x1f7a844198>



False Positive rate --> when it is actually -ve, how often does it predicted +ve = fp/actual-ve = 359/2485 = .14

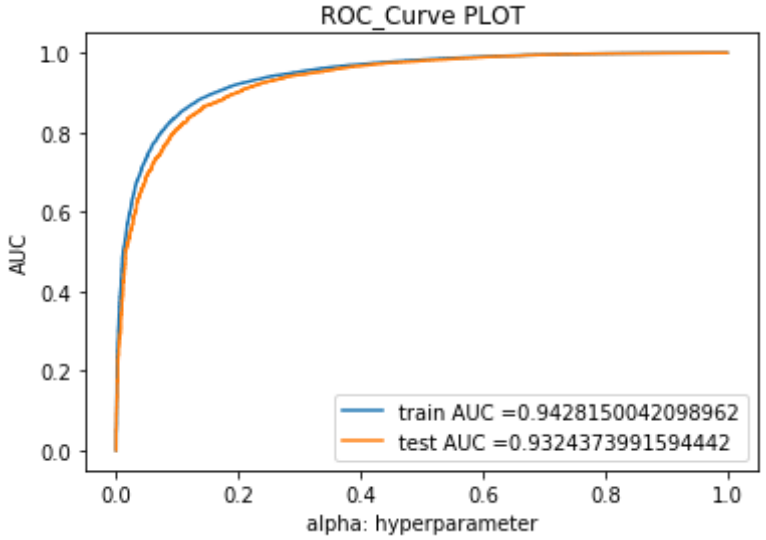
In [186]:
```
# FPR for bowt_l1
bowt_FPR_l1 = .14
```

In [145]:
```
#classification report
from sklearn.metrics import classification_report
print(classification_report(y_ts, pred))
```

```
              precision    recall  f1-score   support

           0       0.45      0.86      0.59      2485
           1       0.98      0.85      0.91     17515
```

```
avg / total       0.91      0.85      0.87     20000
```

In [146]:
```
from sklearn.metrics import roc_curve, auc

train_fpr, train_tpr, thresholds = roc_curve(y_train, sig_clf.predict_p
roba(x_tr_final_counts_bigram)[:,1])
test_fpr, test_tpr, thresholds = roc_curve(y_ts, sig_clf.predict_proba(
x_ts_final_counts_bigram)[:,1])

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, t
rain_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_
tpr)))
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ROC_Curve PLOT")
plt.show()
```

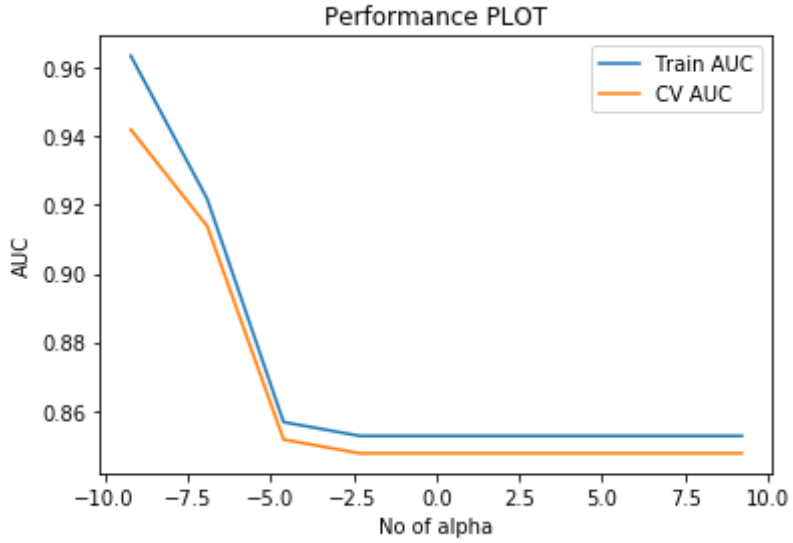


In [147]:
```
# Please write all the code with proper documentation
# Linear kernel svm for L1 penalty
```

```
from sklearn.calibration import CalibratedClassifierCV
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_auc_score

alpha_values = np.arange(10)

acc = np.empty(len(alpha_values))
error = np.empty(len(alpha_values))
C = np.array([0.0001,0.001,0.01,0.1,1,10,100,500,1000,10000])

cv_auc = []
train_auc = []
i = 0
for alpha in C:
    clf = SGDClassifier(loss='hinge',penalty='l2',alpha = alpha,class_w
eight='balanced')
    clf.fit(x_tr_final_counts_bigram, y_train)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(x_tr_final_counts_bigram, y_train)
    y_cv_pred = sig_clf.predict_proba(x_cv_final_counts_bigram)[:,1]
    y_train_pred =  sig_clf.predict_proba(x_tr_final_counts_bigram)[:,1
]

    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

d = max(cv_auc)

i = np.where(cv_auc == d)

i = i[0][0]
best_alpha = float(C[i])
print("Best alpha is:-",best_alpha)


C = np.log(C)


plt.plot(C, train_auc, label='Train AUC')
```

```
plt.plot(C, cv_auc, label='CV AUC')
plt.legend()
plt.xlabel("No of alpha")
plt.ylabel("AUC")
plt.title("Performance PLOT")
plt.show()
```

```
Best alpha is:- 0.0001
```



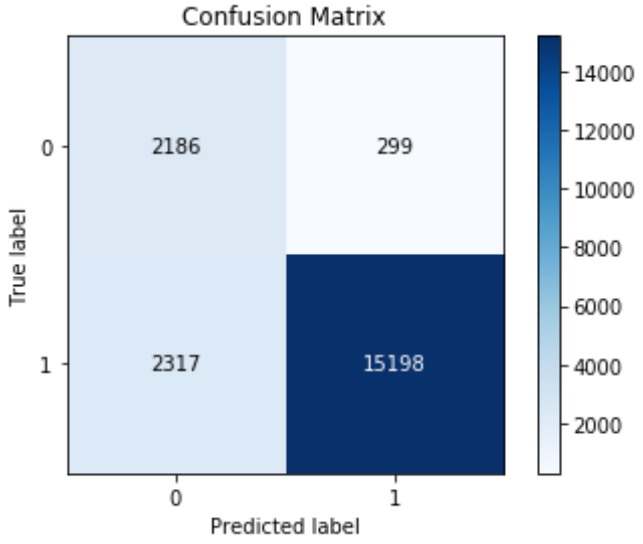
In [148]:
```
# SGDClassifier with best best "alpha" for l2 penalty of bow
model = SGDClassifier(loss='hinge',penalty='l2',alpha = best_alpha,clas
s_weight='balanced')
model.fit(x_tr_final_counts_bigram,y_train)
sig_clf = CalibratedClassifierCV(model, method="sigmoid")
sig_clf.fit(x_tr_final_counts_bigram,y_train)
#pred = model.predict_proba(x_ts_final_counts_bigram)
pred=model.predict(x_ts_final_counts_bigram)
    # evaluate CV AUC
auc_score_bowT_l2 = roc_auc_score(y_true=np.array(y_ts), y_score=sig_cl
f.predict_proba(x_ts_final_counts_bigram)[:,1])*100
auc_score_bowT_lambda_l2 = best_alpha
```

```
print('\nThe AUCScore of the SGDClassifier of best alpha = %f is %f%%'
% (best_alpha, auc_score_bowT_l2))
```

```
The AUCScore of the SGDClassifier of best alpha = 0.000100 is 94.25636
1%
```

In [149]:
```
import scikitplot.metrics as skplt
skplt.plot_confusion_matrix(y_ts ,pred)
```

Out[149]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1f7a9faa58>
```



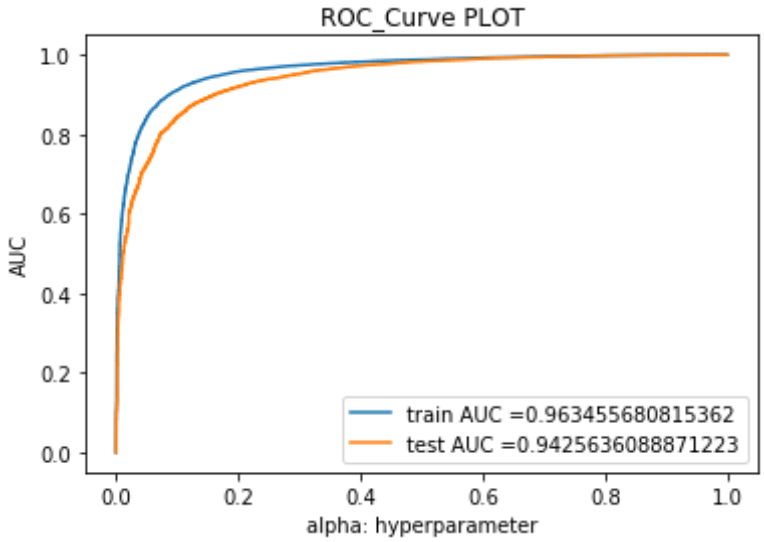
False Positive rate --> when it is actually -ve, how often does it predicted +ve = fp/actual-ve = 299/2485 = .12

In [187]:
```
# FPR for bowt_l2
bowt_FPR_l2 = .12
```

In [150]:
```
#classification report
from sklearn.metrics import classification_report
print(classification_report(y_ts, pred))
```

	precision	recall	f1-score	support
0	0.49	0.88	0.63	2485
1	0.98	0.87	0.92	17515
avg / total	0.92	0.87	0.88	20000

In [151]:
```
from sklearn.metrics import roc_curve, auc

train_fpr, train_tpr, thresholds = roc_curve(y_train, sig_clf.predict_p
roba(x_tr_final_counts_bigram)[:,1])
test_fpr, test_tpr, thresholds = roc_curve(y_ts, sig_clf.predict_proba(
x_ts_final_counts_bigram)[:,1])

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, t
rain_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_
tpr)))
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ROC_Curve PLOT")
plt.show()
```



Top 10 important features of positive class and Negative class

In [134]:
```
# Please write all the code with proper documentation
# To get all the features name
features = count_vect.get_feature_names()
print("some sample features(unique words in the corpus)",features[100:110])
```

```
some sample features(unique words in the corpus) ['action', 'activ', 'actor', 'actual', 'actual add', 'actual ate', 'actual better', 'actual bit', 'actual bought', 'actual burn']
```

In [135]:
```
#code references :- https://stackoverflow.com/questions/11116697/how-to-get-most-informative-features-for-scikit-learn-classifiers
n = 10
coefs_with_fns = sorted(zip(model.coef_[0],features))
top = zip(coefs_with_fns[:n],coefs_with_fns[:-(n+1):-1])
```

In [136]:
```
print("\t\tNegative\t\t\tPositive")
print("_"*80)
```

```
for (coef_1, fn_1), (coef_2, fn_2) in top:
    print("\t%.4f\t%-15s\t\t%.4f\t%-15s" % (coef_1, fn_1, coef_2, fn_2
))
```

```
                Negative                        Positive
_____________________________________________________________________
_________
         -4.5441 disappoint              4.4173  delici
         -3.9053 worst                   4.3986  best
         -3.1496 terribl                 4.0786  excel
         -3.0563 stale                   3.9821  perfect
         -2.9510 unfortun                3.8513  great
         -2.7984 bland                   3.4021  high recommend
         -2.6128 aw                      3.1976  favorit
         -2.5991 return                  3.0677  amaz
         -2.5345 horribl                 2.9748  wonder
         -2.4838 thought                 2.9624  nice
```

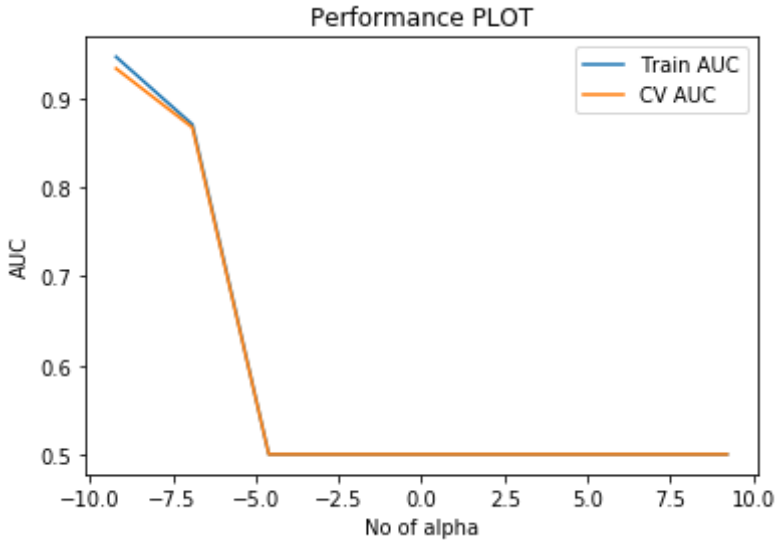
[5.1.2] Applying Linear SVM on TFIDF, SET 2

In [152]:

```
# Please write all the code with proper documentation
# Linear kernel svm for L1 penalty
from sklearn.calibration import CalibratedClassifierCV
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_auc_score

alpha_values = np.arange(10)

acc = np.empty(len(alpha_values))
error = np.empty(len(alpha_values))
C = np.array([0.0001,0.001,0.01,0.1,1,10,100,500,1000,10000])

cv_auc = []
train_auc = []
i = 0
for alpha in C:
    clf = SGDClassifier(loss='hinge',penalty='l1',alpha = alpha,class_w
eight='balanced')
```

```
    clf.fit(x_tr_final_counts_tfidf, y_train)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(x_tr_final_counts_tfidf, y_train)
    y_cv_pred = sig_clf.predict_proba(x_cv_final_counts_tfidf)[:,1]
    y_train_pred =  sig_clf.predict_proba(x_tr_final_counts_tfidf)[:,1]

    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

d = max(cv_auc)

i = np.where(cv_auc == d)

i = i[0][0]
best_alpha = float(C[i])
print("Best alpha is:-",best_alpha)


C = np.log(C)


plt.plot(C, train_auc, label='Train AUC')
plt.plot(C, cv_auc, label='CV AUC')
plt.legend()
plt.xlabel("No of alpha")
plt.ylabel("AUC")
plt.title("Performance PLOT")
plt.show()
```

```
Best alpha is:- 0.0001
```

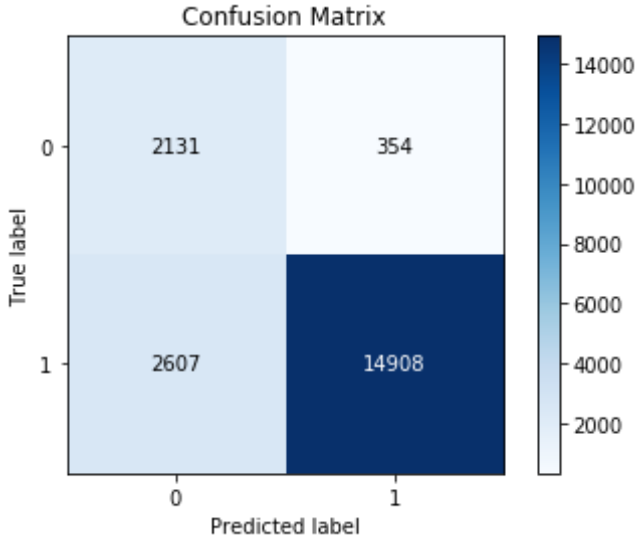


In [153]:
```
# SGDClassifier with best best "alpha" for l1 penalty of TFIDF
model = SGDClassifier(loss='hinge',penalty='l1',alpha = best_alpha,clas
s_weight='balanced')
model.fit(x_tr_final_counts_tfidf,y_train)
sig_clf = CalibratedClassifierCV(model, method="sigmoid")
sig_clf.fit(x_tr_final_counts_tfidf,y_train)
#pred = model.predict_proba(x_ts_final_counts_bigram)
pred=model.predict(x_ts_final_counts_tfidf)
    # evaluate CV AUC
auc_score_tfidf_l1 = roc_auc_score(y_true=np.array(y_ts), y_score=sig_c
lf.predict_proba(x_ts_final_counts_tfidf)[:,1])*100
auc_score_tfidf_lambda_l1 = best_alpha
print('\nThe AUCSscore of the SGDClassifier of best alpha = %f is %f%%'
 % (best_alpha, auc_score_tfidf_l1))
```

```
The AUCSscore of the SGDClassifier of best alpha = 0.000100 is 93.42592
6%
```

In [154]:
```
import scikitplot.metrics as skplt
skplt.plot_confusion_matrix(y_ts ,pred)
```

Out[154]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1f7ab0f550>
```



False Positive rate --> when it is actually -ve, how often does it predicted +ve = fp/actual-ve = 354/2485 = .14

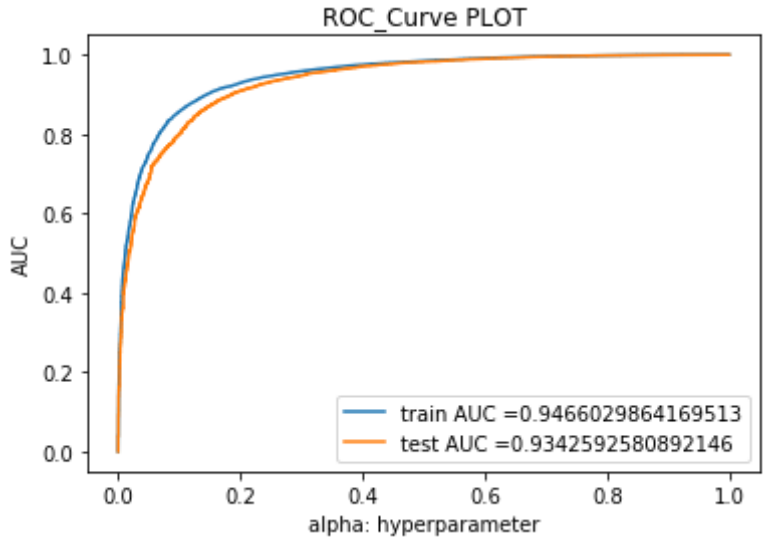
In [188]:
```
# FPR for tfidf_l1
tfidf_FPR_l1 = .14
```

In [155]:
```
print(classification_report(y_ts, pred))
```

```
             precision    recall  f1-score   support

          0       0.45      0.86      0.59      2485
          1       0.98      0.85      0.91     17515

avg / total       0.91      0.85      0.87     20000
```

In [156]:
```
from sklearn.metrics import roc_curve, auc

train_fpr, train_tpr, thresholds = roc_curve(y_train, sig_clf.predict_p
roba(x_tr_final_counts_tfidf)[:,1])
```

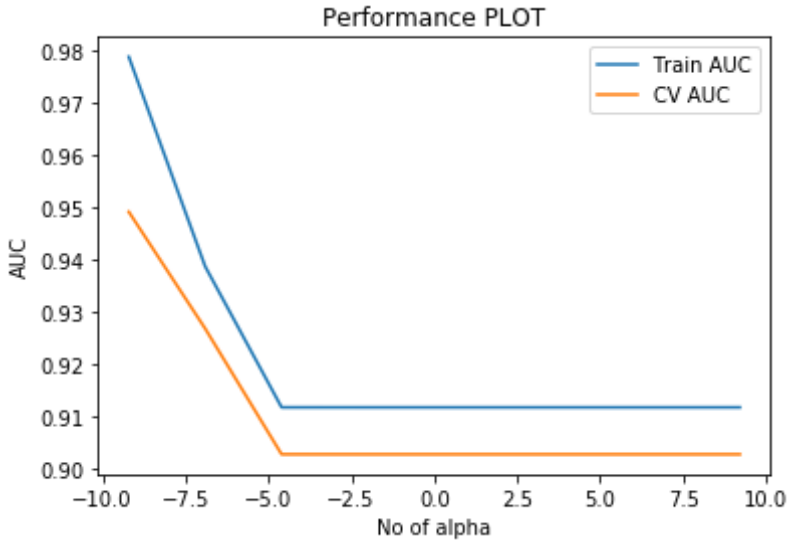
```
test_fpr, test_tpr, thresholds = roc_curve(y_ts, sig_clf.predict_proba(
x_ts_final_counts_tfidf)[:,1])

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, t
rain_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_
tpr)))
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ROC_Curve PLOT")
plt.show()
```



In [157]:
```
# Please write all the code with proper documentation
# Linear kernel svm for L1 penalty
from sklearn.calibration import CalibratedClassifierCV
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_auc_score

alpha_values = np.arange(10)

acc = np.empty(len(alpha_values))
```

```
error = np.empty(len(alpha_values))
C = np.array([0.0001,0.001,0.01,0.1,1,10,100,500,1000,10000])

cv_auc = []
train_auc = []
i = 0
for alpha in C:
    clf = SGDClassifier(loss='hinge',penalty='l2',alpha = alpha,class_w
eight='balanced')
    clf.fit(x_tr_final_counts_tfidf, y_train)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(x_tr_final_counts_tfidf, y_train)
    y_cv_pred = sig_clf.predict_proba(x_cv_final_counts_tfidf)[:,1]
    y_train_pred =  sig_clf.predict_proba(x_tr_final_counts_tfidf)[:,1]

    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

d = max(cv_auc)

i = np.where(cv_auc == d)

i = i[0][0]
best_alpha = float(C[i])
print("Best alpha is:-",best_alpha)


C = np.log(C)


plt.plot(C, train_auc, label='Train AUC')
plt.plot(C, cv_auc, label='CV AUC')
plt.legend()
plt.xlabel("No of alpha")
plt.ylabel("AUC")
plt.title("Performance PLOT")
plt.show()
```

```
Best alpha is:- 0.0001
```

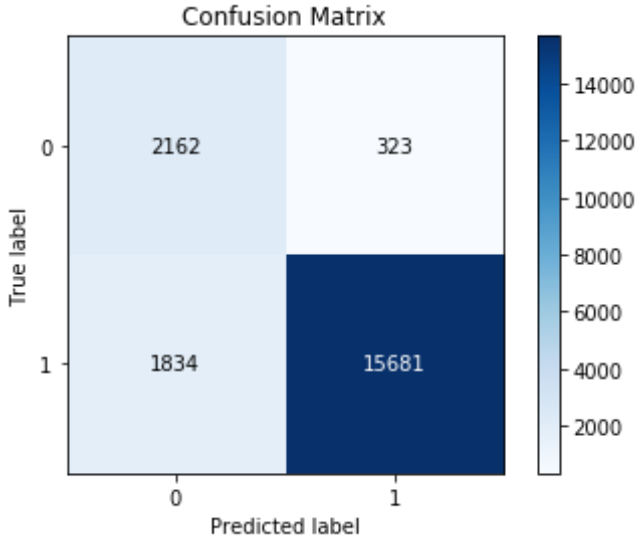


In [158]:
```
# SGDClassifier with best best "alpha" for l2 penalty of TFIDF
model = SGDClassifier(loss='hinge',penalty='l2',alpha = best_alpha,clas
s_weight='balanced')
model.fit(x_tr_final_counts_tfidf,y_train)
sig_clf = CalibratedClassifierCV(model, method="sigmoid")
sig_clf.fit(x_tr_final_counts_tfidf,y_train)
#pred = model.predict_proba(x_ts_final_counts_bigram)
pred=model.predict(x_ts_final_counts_tfidf)
    # evaluate CV AUC
auc_score_tfidf_l2 = roc_auc_score(y_true=np.array(y_ts), y_score=sig_c
lf.predict_proba(x_ts_final_counts_tfidf)[:,1])*100
auc_score_tfidf_lambda_l2 = best_alpha
print('\nThe AUCScore of the SGDClassifier of best alpha = %f is %f%%'
% (best_alpha, auc_score_tfidf_l2))
```

```
The AUCScore of the SGDClassifier of best alpha = 0.000100 is 94.99251
2%
```

In [159]:
```
import scikitplot.metrics as skplt
skplt.plot_confusion_matrix(y_ts ,pred)
```

Out[159]: <matplotlib.axes._subplots.AxesSubplot at 0x1f7ac68320>



False Positive rate --> when it is actually -ve, how often does it predicted +ve = fp/actual-ve = 323/2485 = .25

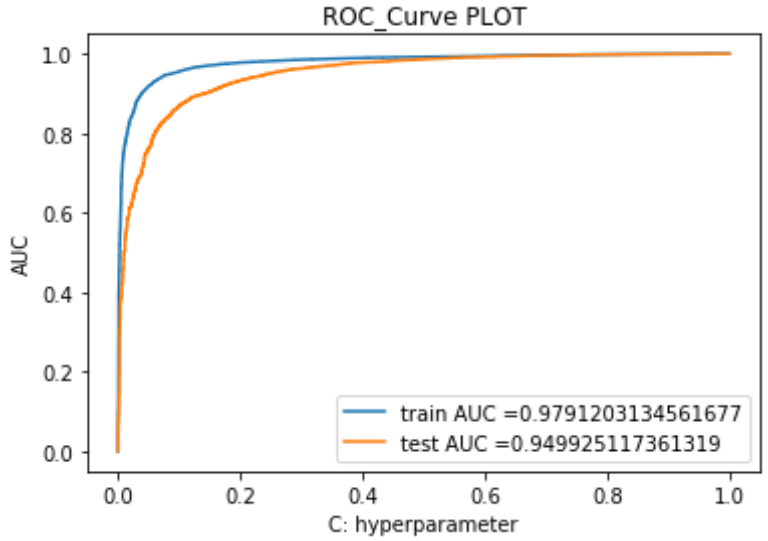
In [189]:
```
# FPR for tfidf_l2
tfidf_FPR_l2 = .12
```

In [160]:
```
print(classification_report(y_ts, pred))
```

```
             precision    recall  f1-score   support

          0       0.54      0.87      0.67      2485
          1       0.98      0.90      0.94     17515

avg / total       0.93      0.89      0.90     20000
```

In [161]:
```
from sklearn.metrics import roc_curve, auc

train_fpr, train_tpr, thresholds = roc_curve(y_train, sig_clf.predict_p
```

```
roba(x_tr_final_counts_tfidf)[:,1])
test_fpr, test_tpr, thresholds = roc_curve(y_ts, sig_clf.predict_proba(
x_ts_final_counts_tfidf)[:,1])

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, t
rain_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_
tpr)))
plt.legend()
plt.xlabel("C: hyperparameter")
plt.ylabel("AUC")
plt.title("ROC_Curve PLOT")
plt.show()
```



Top 10 important features of positive class and Negative class

In [162]:
```
# Please write all the code with proper documentation
# To get all the features name
features = tf_idf_vect.get_feature_names()
print("some sample features(unique words in the corpus)",features[100:1
10])
```

```
some sample features(unique words in the corpus) ['action', 'activ', 'a
ctor', 'actual', 'actual add', 'actual ate', 'actual better', 'actual b
it', 'actual bought', 'actual burn']
```

In [163]:
```
#code references :- https://stackoverflow.com/questions/11116697/how-to
-get-most-informative-features-for-scikit-learn-classifiers
n = 10
coefs_with_fns = sorted(zip(model.coef_[0],features))
top = zip(coefs_with_fns[:n],coefs_with_fns[:-(n+1):-1])
```

In [164]:
```
print("\t\tNegative\t\t\tPositive")
print("_"*80)
for (coef_1, fn_1), (coef_2, fn_2) in top:
    print("\t%.4f\t%-15s\t\t%.4f\t%-15s" % (coef_1, fn_1, coef_2, fn_2
))
```

```
                Negative                        Positive
________________________________________________________________________
_________
        -5.0721 disappoint              6.3499  great
        -3.8446 worst                   5.5806  best
        -3.0185 terribl                 4.8412  delici
        -2.8107 unfortun                4.7984  love
        -2.7478 bland                   4.2121  perfect
        -2.7077 stale                   4.1675  excel
        -2.6410 horribl                 3.4475  favorit
        -2.5758 return                  3.4409  good
        -2.5209 thought                 3.3827  nice
        -2.5111 bad                     3.2437  high recommend
```

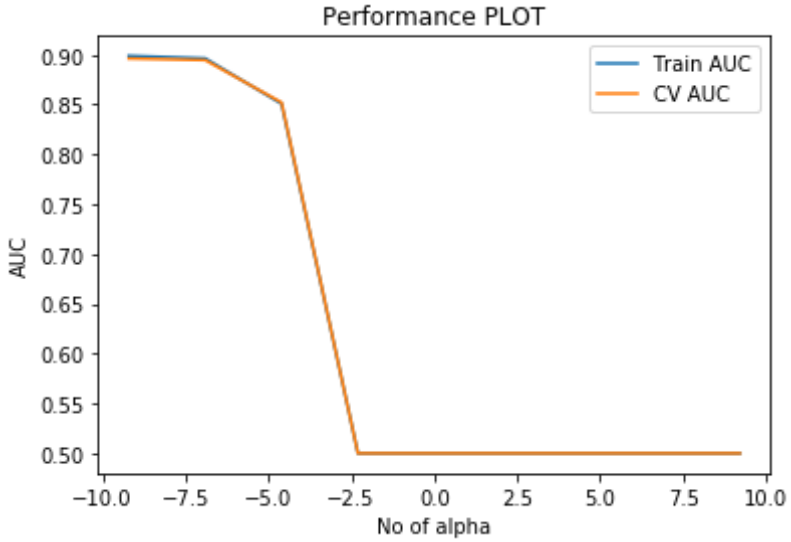
[5.1.3] Applying Linear SVM on AVG W2V, SET 3

In [165]:
```
# Please write all the code with proper documentation
# Linear kernel svm for L1 penalty
from sklearn.calibration import CalibratedClassifierCV
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_auc_score
```

```
alpha_values = np.arange(10)

acc = np.empty(len(alpha_values))
error = np.empty(len(alpha_values))
C = np.array([0.0001,0.001,0.01,0.1,1,10,100,500,1000,10000])

cv_auc = []
train_auc = []
i = 0
for alpha in C:
    clf = SGDClassifier(loss='hinge',penalty='l1',alpha = alpha,class_w
eight='balanced')
    clf.fit(train_avgw2v, y_train)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(train_avgw2v, y_train)
    y_cv_pred = sig_clf.predict_proba(cv_avgw2v)[:,1]
    y_train_pred =  sig_clf.predict_proba(train_avgw2v)[:,1]

    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

d = max(cv_auc)

i = np.where(cv_auc == d)

i = i[0][0]
best_alpha = float(C[i])
print("Best alpha is:-",best_alpha)


C = np.log(C)


plt.plot(C, train_auc, label='Train AUC')
plt.plot(C, cv_auc, label='CV AUC')
plt.legend()
plt.xlabel("No of alpha")
plt.ylabel("AUC")
```

```
plt.title("Performance PLOT")
plt.show()
```

```
Best alpha is:- 0.0001
```

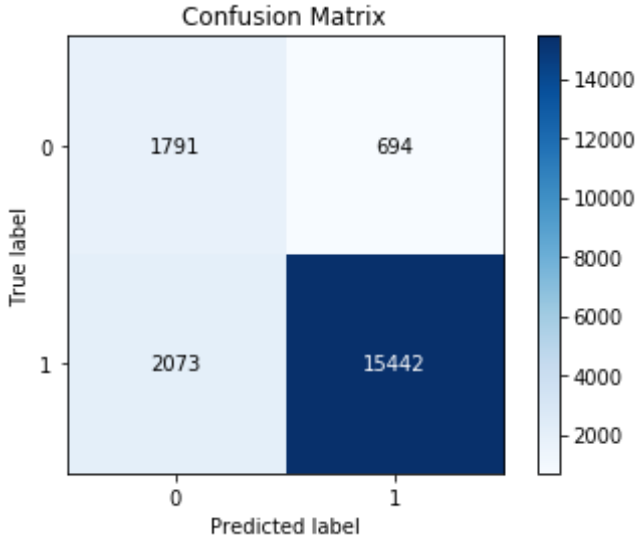


In [166]:
```
# SGDClassifier with best best "alpha" for l1 penalty of avgw2v
model = SGDClassifier(loss='hinge',penalty='l1',alpha = best_alpha,clas
s_weight='balanced')
model.fit(train_avgw2v,y_train)
sig_clf = CalibratedClassifierCV(model, method="sigmoid")
sig_clf.fit(train_avgw2v,y_train)
#pred = model.predict_proba(x_ts_final_counts_bigram)
pred=model.predict(test_avgw2v)
    # evaluate CV AUC
auc_score_avgw2v_l1 = roc_auc_score(y_true=np.array(y_ts), y_score=sig_
clf.predict_proba(test_avgw2v)[:,1])*100
auc_score_avgw2v_lambda_l1 = best_alpha
print('\nThe AUCScore of the SGDClassifier of best alpha = %f is %f%%'
% (best_alpha, auc_score_avgw2v_l1))
```

```
The AUCScore of the SGDClassifier of best alpha = 0.000100 is 89.44165
0%
```

In [167]:
```
import scikitplot.metrics as skplt
skplt.plot_confusion_matrix(y_ts ,pred)
```

Out[167]: <matplotlib.axes._subplots.AxesSubplot at 0x1f7ac685f8>



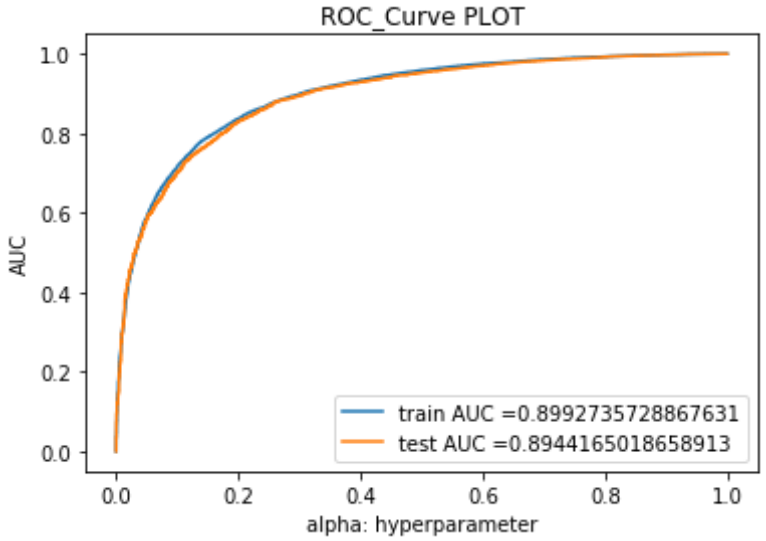
False Positive rate --> when it is actually -ve, how often does it predicted +ve = fp/actual-ve = 694/2485 = .27

In [191]:
```
# FPR for avgw2v_l1
avgw2v_FPR_l1 = .27
```

In [168]:
```
print(classification_report(y_ts, pred))
```

```
             precision    recall  f1-score   support

          0       0.46      0.72      0.56      2485
          1       0.96      0.88      0.92     17515

avg / total       0.90      0.86      0.87     20000
```

In [169]:
```
from sklearn.metrics import roc_curve, auc

train_fpr, train_tpr, thresholds = roc_curve(y_train, sig_clf.predict_p
roba(train_avgw2v)[:,1])
test_fpr, test_tpr, thresholds = roc_curve(y_ts, sig_clf.predict_proba(
test_avgw2v)[:,1])

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, t
rain_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_
tpr)))
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ROC_Curve PLOT")
plt.show()
```

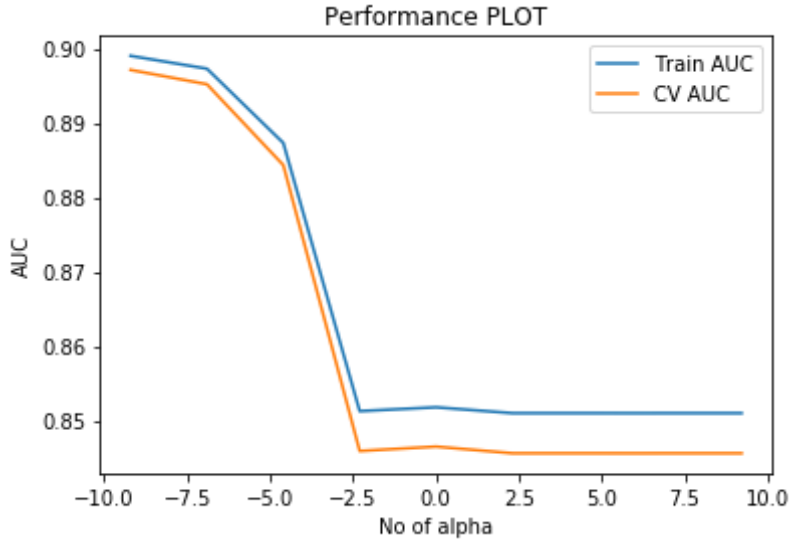


In [170]:
```
# Please write all the code with proper documentation
# Linear kernel svm for L1 penalty
from sklearn.calibration import CalibratedClassifierCV
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_auc_score
```

```
alpha_values = np.arange(10)

acc = np.empty(len(alpha_values))
error = np.empty(len(alpha_values))
C = np.array([0.0001,0.001,0.01,0.1,1,10,100,500,1000,10000])

cv_auc = []
train_auc = []
i = 0
for alpha in C:
    clf = SGDClassifier(loss='hinge',penalty='l2',alpha = alpha,class_w
eight='balanced')
    clf.fit(train_avgw2v, y_train)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(train_avgw2v, y_train)
    y_cv_pred = sig_clf.predict_proba(cv_avgw2v)[:,1]
    y_train_pred =  sig_clf.predict_proba(train_avgw2v)[:,1]

    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

d = max(cv_auc)

i = np.where(cv_auc == d)

i = i[0][0]
best_alpha = float(C[i])
print("Best alpha is:-",best_alpha)


C = np.log(C)


plt.plot(C, train_auc, label='Train AUC')
plt.plot(C, cv_auc, label='CV AUC')
plt.legend()
plt.xlabel("No of alpha")
plt.ylabel("AUC")
```

```
plt.title("Performance PLOT")
plt.show()
```

```
Best alpha is:- 0.0001
```

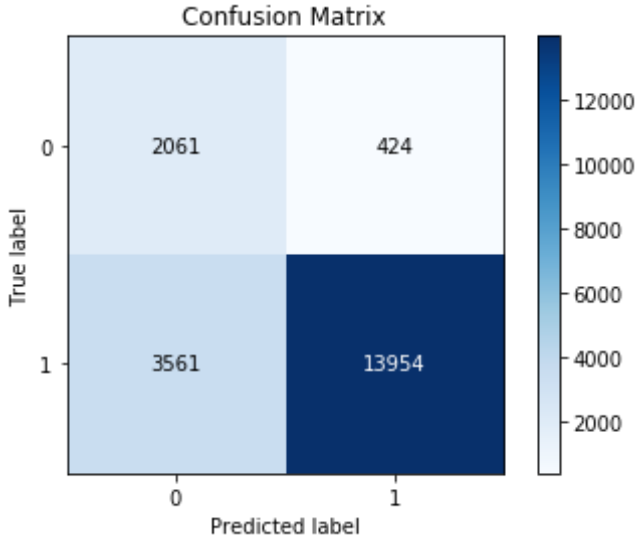


In [171]:
```
# SGDClassifier with best best "alpha" for l2 penalty of avgw2v
model = SGDClassifier(loss='hinge',penalty='l2',alpha = best_alpha,clas
s_weight='balanced')
model.fit(train_avgw2v,y_train)
sig_clf = CalibratedClassifierCV(model, method="sigmoid")
sig_clf.fit(train_avgw2v,y_train)
#pred = model.predict_proba(x_ts_final_counts_bigram)
pred=model.predict(test_avgw2v)
    # evaluate CV AUC
auc_score_avgw2v_l2 = roc_auc_score(y_true=np.array(y_ts), y_score=sig_
clf.predict_proba(test_avgw2v)[:,1])*100
auc_score_avgw2v_lambda_l2 = best_alpha
print('\nThe AUCScore of the SGDClassifier of best alpha = %f is %f%%'
% (best_alpha, auc_score_avgw2v_l2))
```

```
The AUCScore of the SGDClassifier of best alpha = 0.000100 is 89.33678
8%
```

In [172]:
```
import scikitplot.metrics as skplt
skplt.plot_confusion_matrix(y_ts ,pred)
```

Out[172]: <matplotlib.axes._subplots.AxesSubplot at 0x1f7d357fd0>



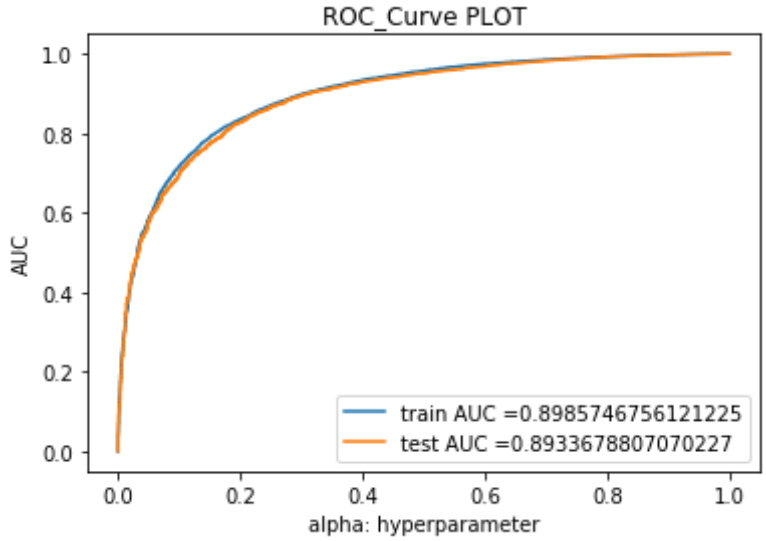
False Positive rate --> when it is actually -ve, how often does it predicted +ve = fp/actual-ve = 424/2485 = .17

In [192]:
```
# FPR for avgw2v_l2
avgw2v_FPR_l2 = .17
```

In [173]:
```
print(classification_report(y_ts, pred))
```

```
             precision    recall  f1-score   support

          0       0.37      0.83      0.51      2485
          1       0.97      0.80      0.88     17515

avg / total       0.90      0.80      0.83     20000
```

In [174]:
```
from sklearn.metrics import roc_curve, auc

train_fpr, train_tpr, thresholds = roc_curve(y_train, sig_clf.predict_p
roba(train_avgw2v)[:,1])
test_fpr, test_tpr, thresholds = roc_curve(y_ts, sig_clf.predict_proba(
test_avgw2v)[:,1])

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, t
rain_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_
tpr)))
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ROC_Curve PLOT")
plt.show()
```



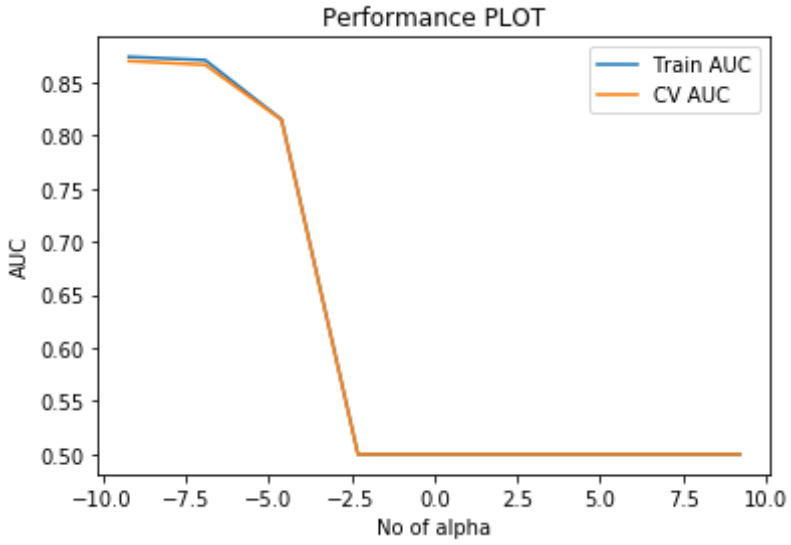
[5.1.4] Applying Linear SVM on TFIDF W2V, SET 4

In [175]:
```
# Please write all the code with proper documentation
# Linear kernel svm for L1 penalty
```

```
from sklearn.calibration import CalibratedClassifierCV
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_auc_score

alpha_values = np.arange(10)

acc = np.empty(len(alpha_values))
error = np.empty(len(alpha_values))
C = np.array([0.0001,0.001,0.01,0.1,1,10,100,500,1000,10000])

cv_auc = []
train_auc = []
i = 0
for alpha in C:
    clf = SGDClassifier(loss='hinge',penalty='l1',alpha = alpha,class_w
eight='balanced')
    clf.fit(tfidf_sent_vectors, y_train)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(tfidf_sent_vectors, y_train)
    y_cv_pred = sig_clf.predict_proba(tfidf_sent_vectors_cv)[:,1]
    y_train_pred =  sig_clf.predict_proba(tfidf_sent_vectors)[:,1]

    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

d = max(cv_auc)

i = np.where(cv_auc == d)

i = i[0][0]
best_alpha = float(C[i])
print("Best alpha is:-",best_alpha)


C = np.log(C)


plt.plot(C, train_auc, label='Train AUC')
plt.plot(C, cv_auc, label='CV AUC')
```

```
plt.legend()
plt.xlabel("No of alpha")
plt.ylabel("AUC")
plt.title("Performance PLOT")
plt.show()
```

```
Best alpha is:- 0.0001
```

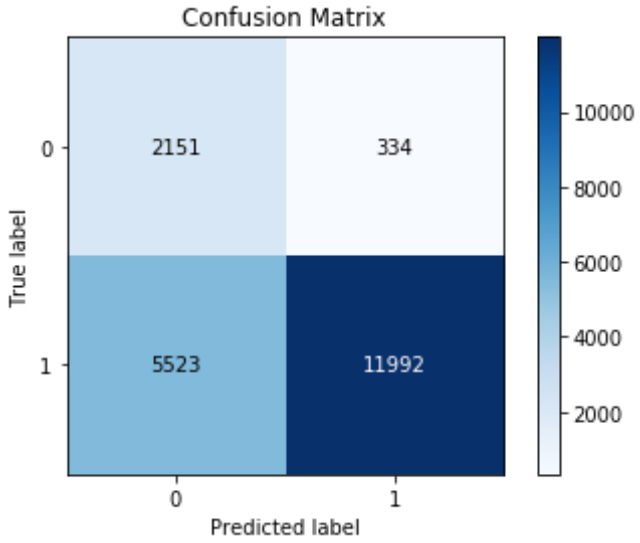


In [176]:
```
# SGDClassifier with best best "alpha" for l1 penalty of tfdidf w2v
model = SGDClassifier(loss='hinge',penalty='l1',alpha = best_alpha,clas
s_weight='balanced')
model.fit(tfidf_sent_vectors,y_train)
sig_clf = CalibratedClassifierCV(model, method="sigmoid")
sig_clf.fit(tfidf_sent_vectors,y_train)
#pred = model.predict_proba(x_ts_final_counts_bigram)
pred=model.predict(tfidf_sent_vectors_ts)
    # evaluate CV AUC
auc_score_sent_vectors_l1 = roc_auc_score(y_true=np.array(y_ts), y_scor
e=sig_clf.predict_proba(tfidf_sent_vectors_ts)[:,1])*100
auc_score_sent_vectors_lambda_l1 = best_alpha
print('\nThe AUCScore of the SGDClassifier of best alpha = %f is %f%%'
% (best_alpha, auc_score_sent_vectors_l1))
```

```
The AUCScore of the SGDClassifier of best alpha = 0.000100 is 86.66385
8%
```

In [177]:
```
import scikitplot.metrics as skplt
skplt.plot_confusion_matrix(y_ts ,pred)
```

Out[177]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1f7b082e80>
```



False Positive rate --> when it is actually -ve, how often does it predicted +ve = fp/actual-ve = 334/2485 = .13

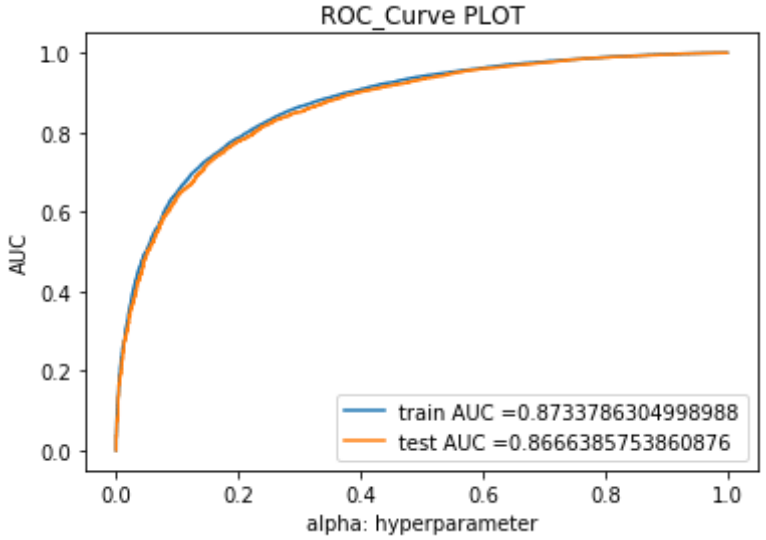
In [204]:
```
# FPR for sent_vectors_l1
sent_vectors_FPR_l1 =.13
```

In [178]:
```
print(classification_report(y_ts, pred))
```

```
              precision    recall  f1-score   support

           0       0.28      0.87      0.42      2485
           1       0.97      0.68      0.80     17515
```

```
avg / total       0.89      0.71      0.76     20000
```

In [179]:
```
from sklearn.metrics import roc_curve, auc

train_fpr, train_tpr, thresholds = roc_curve(y_train, sig_clf.predict_p
roba(tfidf_sent_vectors)[:,1])
test_fpr, test_tpr, thresholds = roc_curve(y_ts, sig_clf.predict_proba(
tfidf_sent_vectors_ts)[:,1])

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, t
rain_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_
tpr)))
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ROC_Curve PLOT")
plt.show()
```

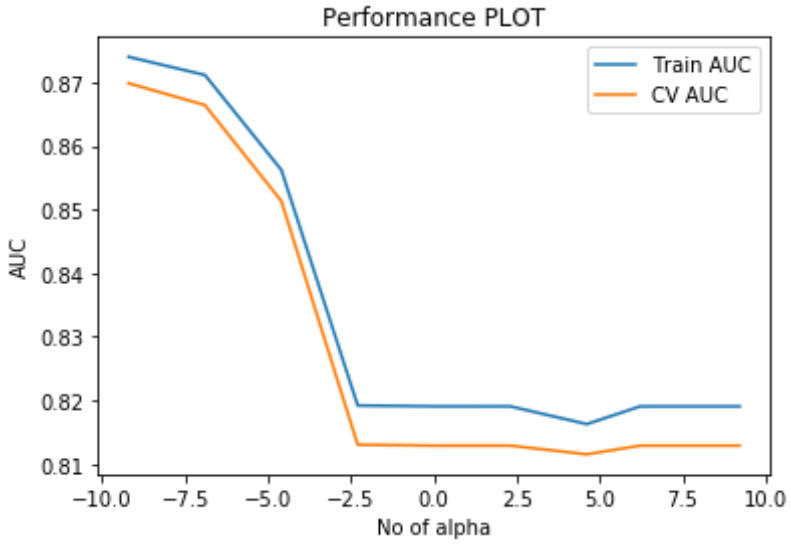


In [180]:
```
# Please write all the code with proper documentation
# Linear kernel svm for L1 penalty
```

```
from sklearn.calibration import CalibratedClassifierCV
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_auc_score

alpha_values = np.arange(10)

acc = np.empty(len(alpha_values))
error = np.empty(len(alpha_values))
C = np.array([0.0001,0.001,0.01,0.1,1,10,100,500,1000,10000])

cv_auc = []
train_auc = []
i = 0
for alpha in C:
    clf = SGDClassifier(loss='hinge',penalty='l2',alpha = alpha,class_w
eight='balanced')
    clf.fit(tfidf_sent_vectors, y_train)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(tfidf_sent_vectors, y_train)
    y_cv_pred = sig_clf.predict_proba(tfidf_sent_vectors_cv)[:,1]
    y_train_pred =  sig_clf.predict_proba(tfidf_sent_vectors)[:,1]

    train_auc.append(roc_auc_score(y_train,y_train_pred))
    cv_auc.append(roc_auc_score(y_cv, y_cv_pred))

d = max(cv_auc)

i = np.where(cv_auc == d)

i = i[0][0]
best_alpha = float(C[i])
print("Best alpha is:-",best_alpha)


C = np.log(C)


plt.plot(C, train_auc, label='Train AUC')
plt.plot(C, cv_auc, label='CV AUC')
```

```
plt.legend()
plt.xlabel("No of alpha")
plt.ylabel("AUC")
plt.title("Performance PLOT")
plt.show()
```

```
Best alpha is:- 0.0001
```

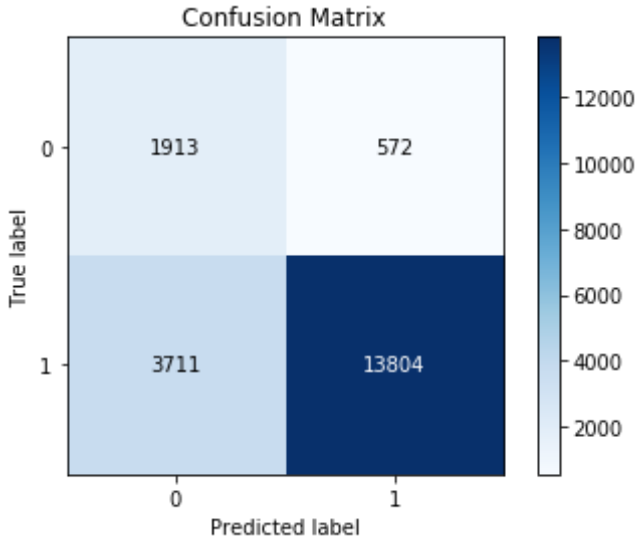


In [181]:
```
# SGDClassifier with best best "alpha" for l2 penalty of TFIDF avgw2v
model = SGDClassifier(loss='hinge',penalty='l2',alpha = best_alpha,clas
s_weight='balanced')
model.fit(tfidf_sent_vectors,y_train)
sig_clf = CalibratedClassifierCV(model, method="sigmoid")
sig_clf.fit(tfidf_sent_vectors,y_train)
#pred = model.predict_proba(x_ts_final_counts_bigram)
pred=model.predict(tfidf_sent_vectors_ts)
    # evaluate CV AUC
auc_score_sent_vectors_l2 = roc_auc_score(y_true=np.array(y_ts), y_scor
e=sig_clf.predict_proba(tfidf_sent_vectors_ts)[:,1])*100
auc_score_sent_vectors_lambda_l2 = best_alpha
print('\nThe AUCScore of the SGDClassifier of best alpha = %f is %f%%'
% (best_alpha, auc_score_sent_vectors_l2))
```

```
The AUCScore of the SGDClassifier of best alpha = 0.000100 is 86.68417
7%
```

In [182]:
```
import scikitplot.metrics as skplt
skplt.plot_confusion_matrix(y_ts ,pred)
```

Out[182]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1f7aa11470>
```



False Positive rate --> when it is actually -ve, how often does it predicted +ve = fp/actual-ve = 572/2485 = .23

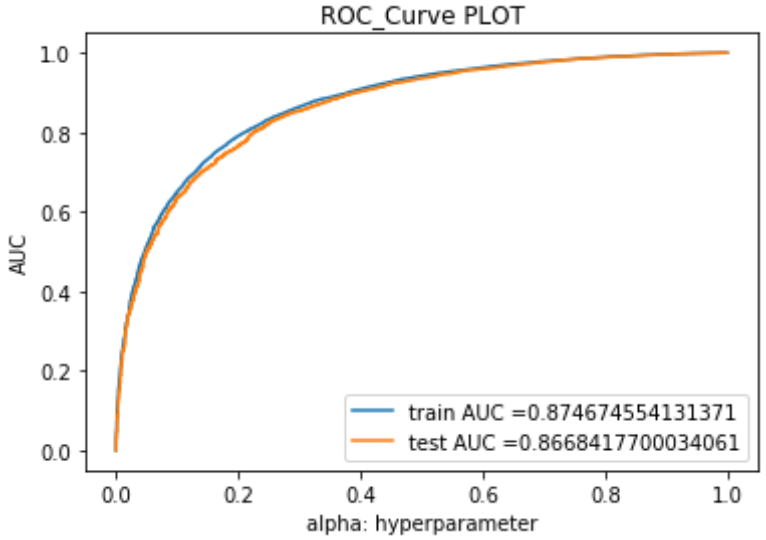
In [195]:
```
# FPR for sent_vectors_l2
sent_vectors_FPR_l2 = .23
```

In [183]:
```
print(classification_report(y_ts, pred))
```

```
              precision    recall  f1-score   support

           0       0.34      0.77      0.47      2485
           1       0.96      0.79      0.87     17515
```

```
avg / total       0.88      0.79      0.82     20000
```

In [184]:
```
from sklearn.metrics import roc_curve, auc

train_fpr, train_tpr, thresholds = roc_curve(y_train, sig_clf.predict_p
roba(tfidf_sent_vectors)[:,1])
test_fpr, test_tpr, thresholds = roc_curve(y_ts, sig_clf.predict_proba(
tfidf_sent_vectors_ts)[:,1])

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, t
rain_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_
tpr)))
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ROC_Curve PLOT")
plt.show()
```



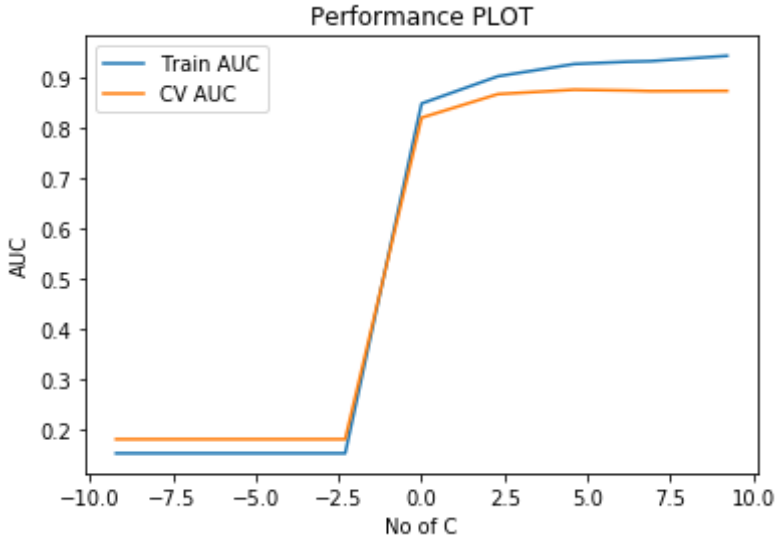
[5.2] RBF SVM

[5.2.1] Applying RBF SVM on BOW, SET 1

In [77]:
```
# Please write all the code with proper documentation
# Linear kernel svm for L1 penalty
from sklearn.calibration import CalibratedClassifierCV
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_auc_score


from sklearn.svm import SVC
alpha_values = np.arange(10)

acc = np.empty(len(alpha_values))
error = np.empty(len(alpha_values))
C = np.array([0.0001,0.001,0.01,0.1,1,10,100,500,1000,10000])

cv_scores = []
tr_scores = []
i = 0
for alpha in C:
    clf = SVC(C = alpha, kernel='rbf',probability=True,class_weight =
'balanced')
    clf.fit(x_tr_final_counts_bigram_rbf, y_train_rbf)
    scores = roc_auc_score(y_true=np.array(y_cv_rbf), y_score=clf.predi
ct_proba(x_cv_final_counts_bigram_rbf)[:,1])
    cv_scores.append(scores)
    scores = roc_auc_score(y_true=np.array(y_train_rbf), y_score=clf.pr
edict_proba(x_tr_final_counts_bigram_rbf)[:,1])
    tr_scores.append(scores)
    i += 1

d = max(cv_scores)

i = np.where(cv_scores == d)
```

```
i = i[0][0]
best_alpha = float(C[i])
print("Best C is:-",best_alpha)


C = np.log(C)


plt.plot(C, tr_scores, label='Train AUC')
plt.plot(C, cv_scores, label='CV AUC')
plt.legend()
plt.xlabel("No of C")
plt.ylabel("AUC")
plt.title("Performance PLOT")
plt.show()
```

```
Best C is:- 100.0
```



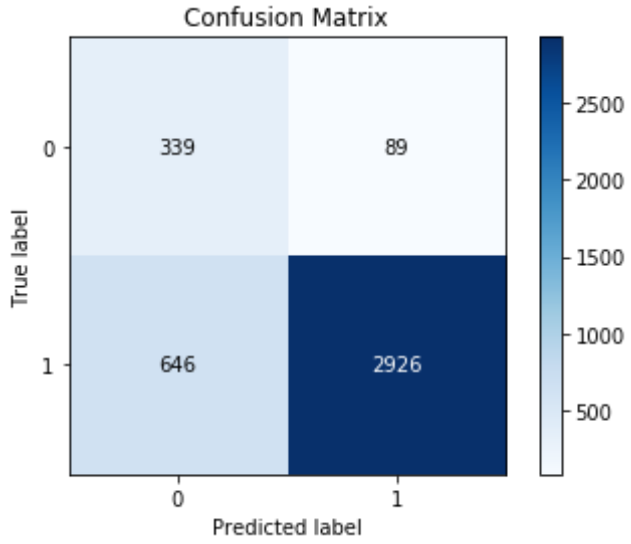
In [78]:
```
# svm RBF with  best C for  bowT
model = SVC(C = best_alpha,kernel='rbf',probability=True,class_weight =
 'balanced')
model.fit(x_tr_final_counts_bigram_rbf,y_train_rbf)
```

```
pred = model.predict(x_ts_final_counts_bigram_rbf)

    # evaluate CV accuracy
auc_score_bowt_rbf = roc_auc_score(y_true=np.array(y_ts_rbf), y_score=m
odel.predict_proba(x_ts_final_counts_bigram_rbf)[:,1])*100
auc_score_bowt_alpha_rbf = best_alpha
print('\nThe AUCScore of SVM of Best C = %f is %f%%' % (best_alpha, auc
_score_bowt_rbf))
```

```
The AUCScore of SVM of Best C = 100.000000 is 87.884186%
```

In [79]:
```
import scikitplot.metrics as skplt
skplt.plot_confusion_matrix(y_ts_rbf ,pred)
```

Out[79]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1f2c264358>
```



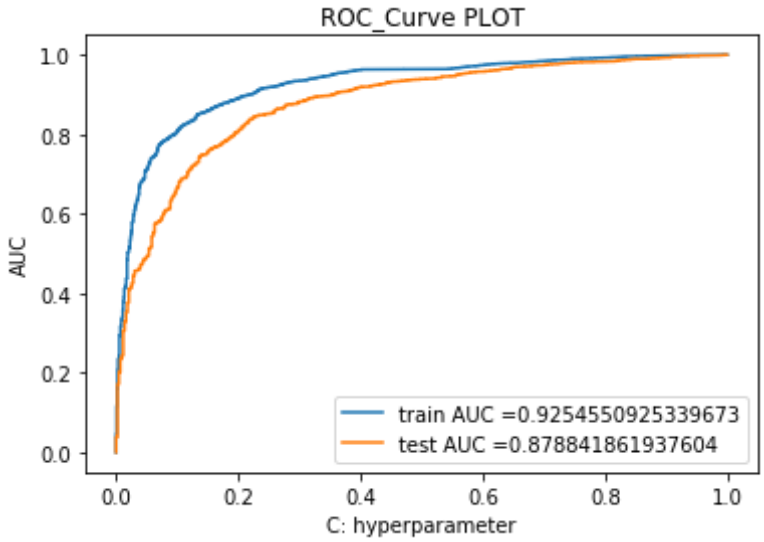
False Positive rate --> when it is actually -ve, how often does it predicted +ve = fp/actual-ve = 89/428 = .20

In [196]:
```
# FPR for bowt_rbf
bowt_rbf_FPR = .20
```

In [80]:
```
#classification report
from sklearn.metrics import classification_report
print(classification_report(y_ts_rbf, pred))
```

```
             precision    recall  f1-score   support

          0       0.34      0.79      0.48       428
          1       0.97      0.82      0.89      3572

avg / total       0.90      0.82      0.84      4000
```

In [81]:
```
from sklearn.metrics import roc_curve, auc

train_fpr, train_tpr, thresholds = roc_curve(y_train_rbf, model.predict
_proba(x_tr_final_counts_bigram_rbf)[:,1])
test_fpr, test_tpr, thresholds = roc_curve(y_ts_rbf, model.predict_prob
a(x_ts_final_counts_bigram_rbf)[:,1])

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, t
rain_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_
tpr)))
plt.legend()
plt.xlabel("C: hyperparameter")
plt.ylabel("AUC")
plt.title("ROC_Curve PLOT")
plt.show()
```

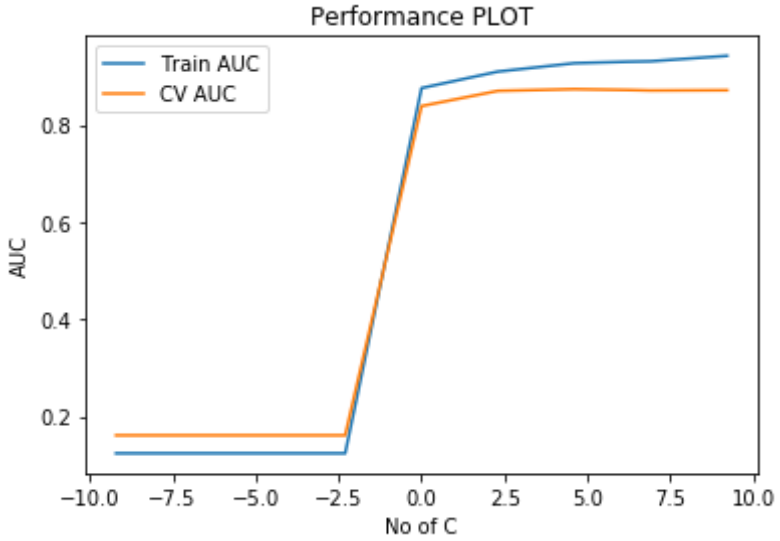


[5.2.2] Applying RBF SVM on TFIDF, SET 2

In [82]:
```
# Please write all the code with proper documentation
# Linear kernel svm for L1 penalty
from sklearn.calibration import CalibratedClassifierCV
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_auc_score


from sklearn.svm import SVC
alpha_values = np.arange(10)

acc = np.empty(len(alpha_values))
error = np.empty(len(alpha_values))
C = np.array([0.0001,0.001,0.01,0.1,1,10,100,500,1000,10000])

cv_scores = []
tr_scores = []
i = 0
for alpha in C:
```

```
    clf = SVC(C = alpha, kernel='rbf',probability=True,class_weight =
'balanced')
    clf.fit(x_tr_final_counts_tfidf_rbf, y_train_rbf)
    scores = roc_auc_score(y_true=np.array(y_cv_rbf), y_score=clf.predi
ct_proba(x_cv_final_counts_tfidf_rbf)[:,1])
    cv_scores.append(scores)
    scores = roc_auc_score(y_true=np.array(y_train_rbf), y_score=clf.pr
edict_proba(x_tr_final_counts_tfidf_rbf)[:,1])
    tr_scores.append(scores)
    i += 1

d = max(cv_scores)

i = np.where(cv_scores == d)

i = i[0][0]
best_alpha = float(C[i])
print("Best C is:-",best_alpha)


C = np.log(C)


plt.plot(C, tr_scores, label='Train AUC')
plt.plot(C, cv_scores, label='CV AUC')
plt.legend()
plt.xlabel("No of C")
plt.ylabel("AUC")
plt.title("Performance PLOT")
plt.show()
```

```
Best C is:- 100.0
```

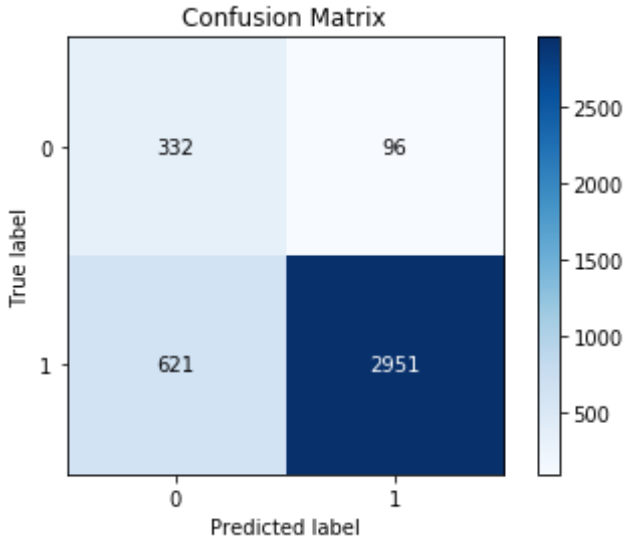


In [83]:
```
# svm RBF with  best C for  tfidf
model = SVC(C = best_alpha,kernel='rbf',probability=True,class_weight =
 'balanced')
model.fit(x_tr_final_counts_tfidf_rbf,y_train_rbf)
pred = model.predict(x_ts_final_counts_tfidf_rbf)

    # evaluate CV accuracy
auc_score_tfidf_rbf = roc_auc_score(y_true=np.array(y_ts_rbf), y_score=
model.predict_proba(x_ts_final_counts_tfidf_rbf)[:,1])*100
auc_score_tfidf_alpha_rbf = best_alpha
print('\nThe AUCScore of SVM of Best C = %f is %f%%' % (best_alpha, auc
_score_tfidf_rbf))
```

```
The AUCScore of SVM of Best C = 100.000000 is 87.678243%
```

In [84]:
```
import scikitplot.metrics as skplt
skplt.plot_confusion_matrix(y_ts_rbf ,pred)
```

Out[84]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1f2c4df320>
```



False Positive rate --> when it is actually -ve, how often does it predicted +ve = fp/actual-ve = 96/428 = .22

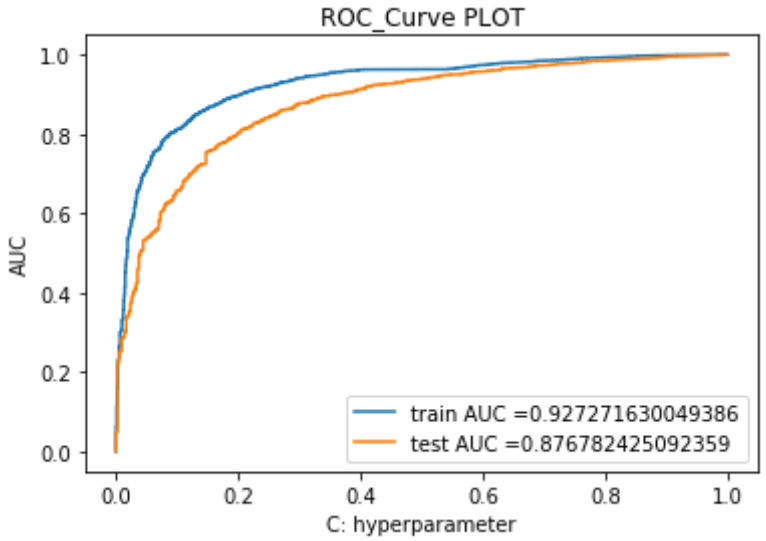
In [197]:
```
# FPR for tfidf
tfidf_rbf_FPR = .22
```

In [85]:
```
print(classification_report(y_ts_rbf, pred))
```

```
             precision    recall  f1-score   support

          0       0.35      0.78      0.48       428
          1       0.97      0.83      0.89      3572

avg / total       0.90      0.82      0.85      4000
```

In [86]:
```
from sklearn.metrics import roc_curve, auc

train_fpr, train_tpr, thresholds = roc_curve(y_train_rbf, model.predict
_proba(x_tr_final_counts_tfidf_rbf)[:,1])
```

```
test_fpr, test_tpr, thresholds = roc_curve(y_ts_rbf, model.predict_prob
a(x_ts_final_counts_tfidf_rbf)[:,1])

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, t
rain_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_
tpr)))
plt.legend()
plt.xlabel("C: hyperparameter")
plt.ylabel("AUC")
plt.title("ROC_Curve PLOT")
plt.show()
```



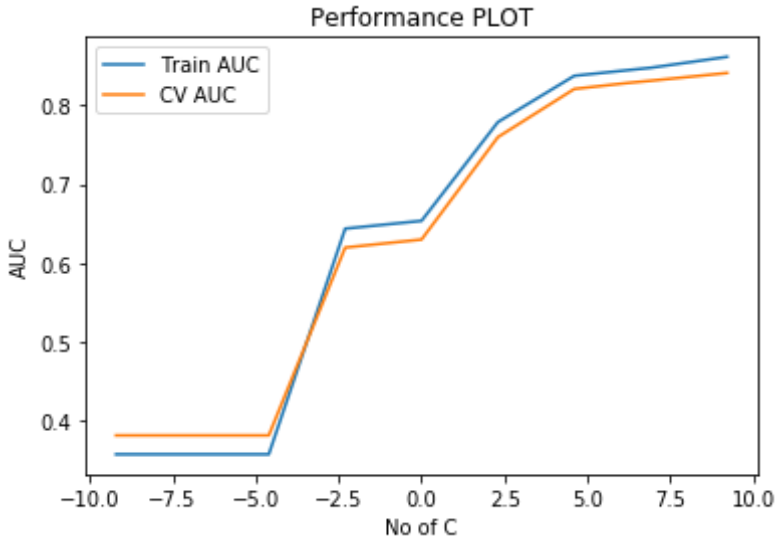
[5.2.3] Applying RBF SVM on AVG W2V, SET 3

In [87]:
```
# Please write all the code with proper documentation
# Linear kernel svm for L1 penalty
from sklearn.calibration import CalibratedClassifierCV
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_auc_score
```

```
from sklearn.svm import SVC
alpha_values = np.arange(10)

acc = np.empty(len(alpha_values))
error = np.empty(len(alpha_values))
C = np.array([0.0001,0.001,0.01,0.1,1,10,100,500,1000,10000])

cv_scores = []
tr_scores = []
i = 0
for alpha in C:
    clf = SVC(C = alpha, kernel='rbf',probability=True,class_weight =
'balanced')
    clf.fit(train_avgw2v_rbf, y_train_rbf)
    scores = roc_auc_score(y_true=np.array(y_cv_rbf), y_score=clf.predi
ct_proba(cv_avgw2v_rbf)[:,1])
    cv_scores.append(scores)
    scores = roc_auc_score(y_true=np.array(y_train_rbf), y_score=clf.pr
edict_proba(train_avgw2v_rbf)[:,1])
    tr_scores.append(scores)
    i += 1

d = max(cv_scores)

i = np.where(cv_scores == d)

i = i[0][0]
best_alpha = float(C[i])
print("Best C is:-",best_alpha)


C = np.log(C)


plt.plot(C, tr_scores, label='Train AUC')
plt.plot(C, cv_scores, label='CV AUC')
plt.legend()
plt.xlabel("No of C")
```

```
plt.ylabel("AUC")
plt.title("Performance PLOT")
plt.show()
```

```
Best C is:- 10000.0
```



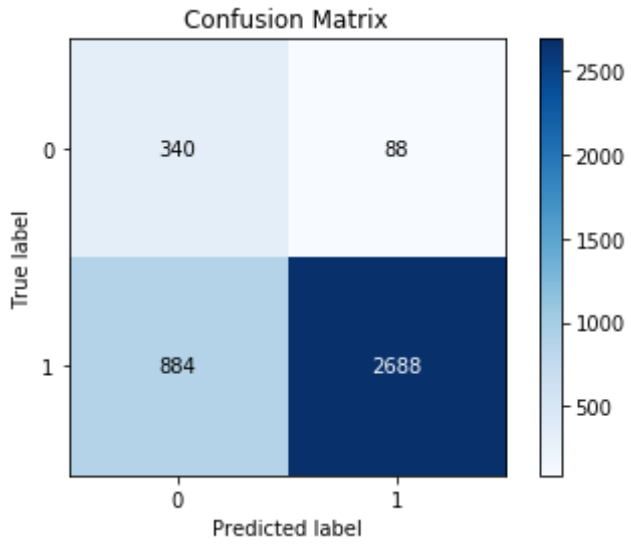
In [88]:
```
# svm RBF with  best C for  avgw2v
model = SVC(C = best_alpha,kernel='rbf',probability=True,class_weight =
 'balanced')
model.fit(train_avgw2v_rbf,y_train_rbf)
pred = model.predict(test_avgw2v_rbf)

    # evaluate CV accuracy
auc_score_avgword2vec = roc_auc_score(y_true=np.array(y_ts_rbf), y_scor
e=model.predict_proba(test_avgw2v_rbf)[:,1])*100
auc_score_avgword2vec_alpha_rbf = best_alpha
print('\nThe AUCScore of SVM of Best C = %f is %f%%' % (best_alpha, auc
_score_avgword2vec))
```

```
The AUCScore of SVM of Best C = 10000.000000 is 84.540259%
```

In [89]:
```
import scikitplot.metrics as skplt
```

```
skplt.plot_confusion_matrix(y_ts_rbf,pred)
```

Out[89]: <matplotlib.axes._subplots.AxesSubplot at 0x1f2c3ae6d8>



False Positive rate --> when it is actually -ve, how often does it predicted +ve = fp/actual-ve = 88/428 = .20

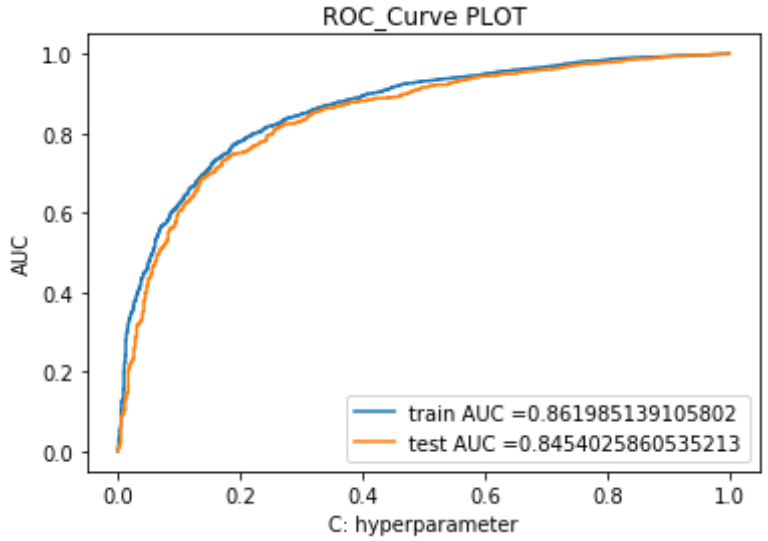
In [198]:
```
# FPR for avg2wec
avgw2v_rbf_FPR = .20
```

In [90]:
```
print(classification_report(y_ts_rbf, pred))
```

```
             precision    recall  f1-score   support

          0       0.28      0.79      0.41       428
          1       0.97      0.75      0.85      3572

avg / total       0.89      0.76      0.80      4000
```

In [91]:
```
from sklearn.metrics import roc_curve, auc
```

```
train_fpr, train_tpr, thresholds = roc_curve(y_train_rbf, model.predict
_proba(train_avgw2v_rbf)[:,1])
test_fpr, test_tpr, thresholds = roc_curve(y_ts_rbf, model.predict_prob
a(test_avgw2v_rbf)[:,1])

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, t
rain_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_
tpr)))
plt.legend()
plt.xlabel("C: hyperparameter")
plt.ylabel("AUC")
plt.title("ROC_Curve PLOT")
plt.show()
```



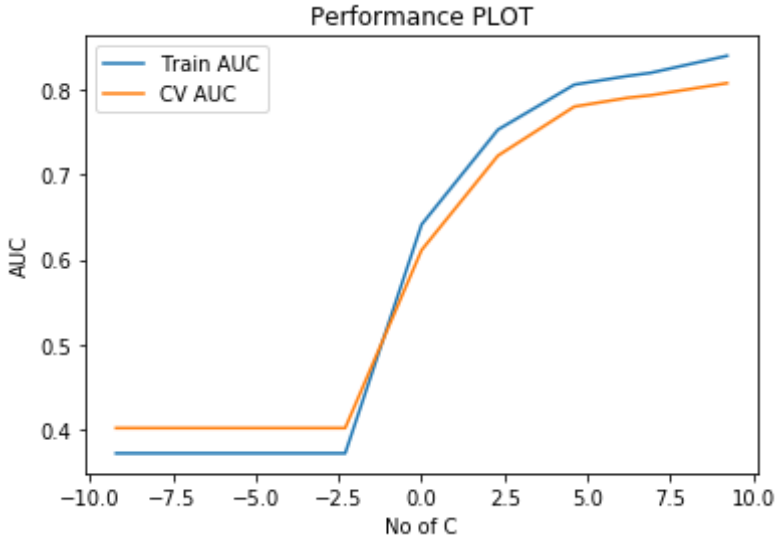
[5.2.4] Applying RBF SVM on TFIDF W2V, SET 4

In [92]:
```
# Please write all the code with proper documentation
# Linear kernel svm for L1 penalty
from sklearn.calibration import CalibratedClassifierCV
```

```
from sklearn.linear_model import SGDClassifier
from sklearn.metrics import roc_auc_score


from sklearn.svm import SVC
alpha_values = np.arange(10)

acc = np.empty(len(alpha_values))
error = np.empty(len(alpha_values))
C = np.array([0.0001,0.001,0.01,0.1,1,10,100,500,1000,10000])

cv_scores = []
tr_scores = []
i = 0
for alpha in C:
    clf = SVC(C = alpha, kernel='rbf',probability=True,class_weight =
'balanced')
    clf.fit(tfidf_sent_vectors_rbf, y_train_rbf)
    scores = roc_auc_score(y_true=np.array(y_cv_rbf), y_score=clf.predi
ct_proba(tfidf_sent_vectors_cv_rbf)[:,1])
    cv_scores.append(scores)
    scores = roc_auc_score(y_true=np.array(y_train_rbf), y_score=clf.pr
edict_proba(tfidf_sent_vectors_rbf)[:,1])
    tr_scores.append(scores)
    i += 1

d = max(cv_scores)

i = np.where(cv_scores == d)

i = i[0][0]
best_alpha = float(C[i])
print("Best C is:-",best_alpha)


C = np.log(C)


plt.plot(C, tr_scores, label='Train AUC')
```

```
plt.plot(C, cv_scores, label='CV AUC')
plt.legend()
plt.xlabel("No of C")
plt.ylabel("AUC")
plt.title("Performance PLOT")
plt.show()
```

```
Best C is:- 10000.0
```

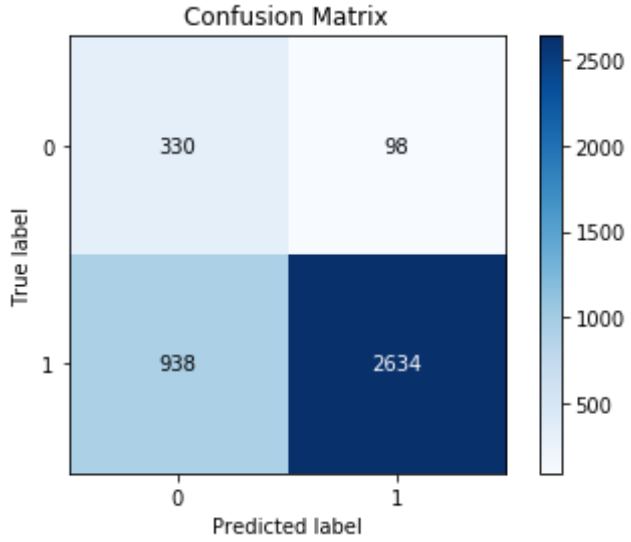


In [93]:
```
# svm RBF with  best C for tfidf avgw2v
model = SVC(C = best_alpha,kernel='rbf',probability=True,class_weight =
 'balanced')
model.fit(tfidf_sent_vectors_rbf,y_train_rbf)
pred = model.predict(tfidf_sent_vectors_ts_rbf)

    # evaluate CV accuracy
auc_score_tfidf_we_rbf = roc_auc_score(y_true=np.array(y_ts_rbf), y_sco
re=model.predict_proba(tfidf_sent_vectors_ts_rbf)[:,1])*100
auc_score_tfidf_we_alpha_rbf = best_alpha
print('\nThe AUCScore of SVM of Best C = %f is %f%%' % (best_alpha, auc
_score_tfidf_we_rbf))
```

```
The AUCScore of SVM of Best C = 10000.000000 is 82.056016%
```

In [94]:
```
import scikitplot.metrics as skplt
skplt.plot_confusion_matrix(y_ts_rbf,pred)
```

Out[94]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x1f2c5aaa20>
```



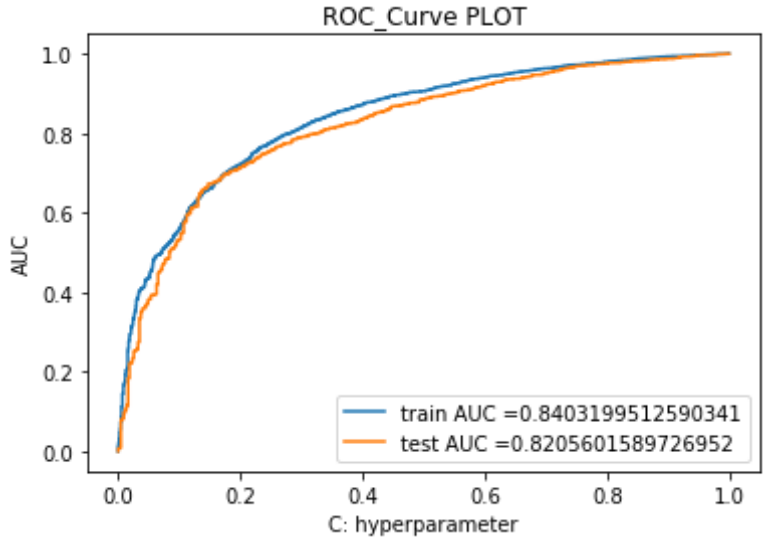
False Positive rate --> when it is actually -ve, how often does it predicted +ve = fp/actual-ve = 98/428 = .22

In [199]:
```
# FPR for tfidf_we
tfidf_we_rbf_FPR = .22
```

In [95]:
```
print(classification_report(y_ts_rbf, pred))
```

```
             precision    recall  f1-score   support

          0       0.26      0.77      0.39       428
          1       0.96      0.74      0.84      3572

avg / total       0.89      0.74      0.79      4000
```

In [96]:
```
from sklearn.metrics import roc_curve, auc

train_fpr, train_tpr, thresholds = roc_curve(y_train_rbf, model.predict
_proba(tfidf_sent_vectors_rbf)[:,1])
test_fpr, test_tpr, thresholds = roc_curve(y_ts_rbf, model.predict_prob
a(tfidf_sent_vectors_ts_rbf)[:,1])

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, t
rain_tpr)))
plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_
tpr)))
plt.legend()
plt.xlabel("C: hyperparameter")
plt.ylabel("AUC")
plt.title("ROC_Curve PLOT")
plt.show()
```



[6] Conclusions

In [208]:
```
# Please compare all your models using Prettytable library

from prettytable import PrettyTable
x = PrettyTable()
x.field_names = ["SVM","Vectorizer","penalty","hyperparameter","roc_auc
_score","FPR"]
x.add_row(["Linear SVM","BOW","L1",auc_score_bowT_lambda_l1,auc_score_b
owT_l1,bowt_FPR_l1])
x.add_row(["Linear SVM","BOW","L2",auc_score_bowT_lambda_l2,auc_score_b
owT_l2,bowt_FPR_l2])
x.add_row(["Linear SVM","TF-IDF","L1",auc_score_tfidf_lambda_l1,auc_sco
re_tfidf_l1,tfidf_FPR_l1])
x.add_row(["Linear SVM","TF-IDF","L2",auc_score_tfidf_lambda_l2,auc_sco
re_tfidf_l2,tfidf_FPR_l2])
x.add_row(["Linear SVM","AVG -W2V","L1",auc_score_avgw2v_lambda_l1,auc_
score_avgw2v_l1,avgw2v_FPR_l1])
x.add_row(["Linear SVM","AVG -W2V","L2",auc_score_avgw2v_lambda_l2,auc_
score_avgw2v_l2,avgw2v_FPR_l2])
x.add_row(["Linear SVM","TFIDF-W2V","L1",auc_score_sent_vectors_lambda_
l1,auc_score_sent_vectors_l1,sent_vectors_FPR_l1])
x.add_row(["Linear SVM","TFIDF-W2V","L2",auc_score_sent_vectors_lambda_
l2,auc_score_sent_vectors_l2,sent_vectors_FPR_l2])
x.add_row(["RBF SVM","BOW","NA",auc_score_bowt_alpha_rbf,auc_score_bowt
_rbf,bowt_rbf_FPR])
x.add_row(["RBF SVM","TFIDF","NA",auc_score_tfidf_alpha_rbf,auc_score_t
fidf_rbf,tfidf_rbf_FPR])
x.add_row(["RBF SVM","avgw2v","NA",auc_score_avgword2vec_alpha_rbf,auc_
score_avgword2vec,avgw2v_rbf_FPR])
x.add_row(["RBF SVM","TFIDF W2V","NA",auc_score_tfidf_we_alpha_rbf,auc_
score_tfidf_we_rbf,tfidf_we_rbf_FPR])



print(x)
```

```
+-----------+-----------+---------+---------------+----------------
--+------+
|    SVM    | Vectorizer | penalty | hyperparameter |   roc_auc_score
  | FPR  |
+-----------+-----------+---------+---------------+----------------
```

```
--+------+
| Linear SVM |    BOW     |    L1   |     0.0001     | 93.2437399159444
2 | 0.14 |
| Linear SVM |    BOW     |    L2   |     0.0001     | 94.2563608887122
4 | 0.12 |
| Linear SVM |   TF-IDF   |    L1   |     0.0001     | 93.4259258089214
6 | 0.14 |
| Linear SVM |   TF-IDF   |    L2   |     0.0001     |  94.992511736131
9 | 0.12 |
| Linear SVM |  AVG -W2V  |    L1   |     0.0001     | 89.4416501865891
3 | 0.27 |
| Linear SVM |  AVG -W2V  |    L2   |     0.0001     | 89.3367880707022
7 | 0.17 |
| Linear SVM | TFIDF-W2V  |    L1   |     0.0001     | 86.6638575386087
5 | 0.13 |
| Linear SVM | TFIDF-W2V  |    L2   |     0.0001     | 86.6841770003406
1 | 0.23 |
|  RBF SVM   |    BOW     |    NA   |      100.0     |  87.884186193760
4 | 0.2  |
|  RBF SVM   |   TFIDF    |    NA   |      100.0     |  87.678242509235
9 | 0.22 |
|  RBF SVM   |   avgw2v   |    NA   |    10000.0     | 84.5402586053521
2 | 0.2  |
|  RBF SVM   | TFIDF W2V  |    NA   |    10000.0     | 82.0560158972695
2 | 0.22 |
+------------+------------+---------+----------------+----------------
--+------+
```

as per the table, we can consider TFIDF with L2 regularizor(Linear SVM) because it has less false positive rate and more roc_auc_score