READING THE DATA

In [52]:

```
%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
```

In [53]:

```
# using SQLite Table to read data.
con = sqlite3.connect('C:/Users/sesha/OneDrive/Desktop/ICONS/IMP/before/MINIPJ/Personal/AMAZON food review 2/database.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 500000 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 Score != 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 LIMIT 100000""", con)

# Give reviews with Score>3 a positive rating(1), and reviews with a score<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 (100000, 10)
```

Out[53]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	Time	Summary
0	1	B001E4KFG0	A3SGXH7AUHU8GW	delmartian	1	1	1	1303862400	Good Quality Dog Food
1	2	B00813GRG4	A1D87F6ZCVE5NK	dll pa	0	0	0	1346976000	Not as Advertised
2	3	B000LQOCH0	ABXLMWJIXXAIN	Natalia Corres "Natalia Corres"	1	1	1	1219017600	"Delight" says it all

In [54]:

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

In [55]:

```
display[display['UserId']=='AZY10LLTJ71NX']
```

Out[55]:

	UserId	ProductId	ProfileName	Time	Score	Text	COUNT(*)
80638	AZY10LLTJ71NX	B001ATMQK2	undertheshrine "undertheshrine"	1296691200	5	I bought this 6 pack because for the price tha...	5

In [56]:

```
display['COUNT(*)'].sum()
```

Out[56]:

393063

EXPLORATORY DATA ANALYSIS

In [57]:

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

Out[57]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	Time	Summ
				Geetha					LOACK QUADRA

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	Time	Summ
0	78445	B000HDL1RQ	AR5J8UI46CURR	Geetha Krishnan	2	2	5	1199577600	QUADRA VANI WAFE
1	138317	B000HDOPYC	AR5J8UI46CURR	Geetha Krishnan	2	2	5	1199577600	LOACK QUADRA VANI WAFE
2	138277	B000HDOPYM	AR5J8UI46CURR	Geetha Krishnan	2	2	5	1199577600	LOACK QUADRA VANI WAFE
3	73791	B000HDOPZG	AR5J8UI46CURR	Geetha Krishnan	2	2	5	1199577600	LOACK QUADRA VANI WAFE
4	155049	B000PAQ75C	AR5J8UI46CURR	Geetha Krishnan	2	2	5	1199577600	LOACK QUADRA VANI WAFE

In [58]:

```
#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 [59]:

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

Out[59]:

```
(87775, 10)
```

In [60]:

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

Out[60]:

```
87.775
```

In [61]:

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

display.head()
```

Out[61]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	Time	Summary
0	64422	B000MIDROQ	A161DK06JJMCYF	J. E. Stephens "Jeanne"	3	1	5	1224892800	Bought This for My Son at College

Pure

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	Time	Summary
1	44737	B001EQ55RW	A2V0I904FH7ABY	Ram	3	2	4	1212883200	cocoa taste with crunchy almonds inside

In [62]:

```
final=final[final.HelpfulnessNumerator<=final.HelpfulnessDenominator]
```

In [63]:

```
#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()
```

```
(87773, 10)
```

Out[63]:

```
1    73592
0    14181
Name: Score, dtype: int64
```

PREPROCESSING

In [64]:

```
# 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)
```

```
My dogs loves this chicken but its a product from China, so we wont be buying it anymore.  Its ver
y hard to find any chicken products made in the USA but they are out there, but this one isnt.  It
s too bad too because its a good product but I wont take any chances till they know what is going
on with the china imports.
==================================================
The Candy Blocks were a nice visual for the Lego Birthday party but the candy has little taste to
it.  Very little of the 2 lbs that I bought were eaten and I threw the rest away.  I would not buy
the candy again.
==================================================
was way to hot for my blood, took a bite and did a jig  lol
==================================================
My dog LOVES these treats. They tend to have a very strong fish oil smell. So if you are afraid of
the fishy smell, don't get it. But I think my dog likes it because of the smell. These treats are
really small in size. They are great for training. You can give your dog several of these without
worrying about him over eating. Amazon's price was much more reasonable than any other retailer. Y
ou can buy a 1 pound bag on Amazon for almost the same price as a 6 ounce bag at other retailers.
It's definitely worth it to buy a big bag if your dog eats them a lot.
==================================================
```

In [65]:

```
# remove urls from text python: https://stackoverflow.com/a/40823105/4084039
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)
```

```
My dogs loves this chicken but its a product from China, so we wont be buying it anymore.  Its ver
y hard to find any chicken products made in the USA but they are out there, but this one isnt.  It
s too bad too because its a good product but I wont take any chances till they know what is going
on with the china imports.
```

In [66]:

```
# 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)
```

```
My dogs loves this chicken but its a product from China, so we wont be buying it anymore.  Its ver
y hard to find any chicken products made in the USA but they are out there, but this one isnt.  It
s too bad too because its a good product but I wont take any chances till they know what is going
on with the china imports.
==================================================
The Candy Blocks were a nice visual for the Lego Birthday party but the candy has little taste to
it.  Very little of the 2 lbs that I bought were eaten and I threw the rest away.  I would not buy
the candy again.
==================================================
was way to hot for my blood, took a bite and did a jig  lol
==================================================
My dog LOVES these treats. They tend to have a very strong fish oil smell. So if you are afraid of
the fishy smell, don't get it. But I think my dog likes it because of the smell. These treats are
really small in size. They are great for training. You can give your dog several of these without
worrying about him over eating. Amazon's price was much more reasonable than any other retailer. Y
ou can buy a 1 pound bag on Amazon for almost the same price as a 6 ounce bag at other retailers.
It's definitely worth it to buy a big bag if your dog eats them a lot.
```

In [67]:

```
# 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 [68]:

```
sent_1500 = decontracted(sent_1500)
print(sent_1500)
print("="*50)
```

```
was way to hot for my blood, took a bite and did a jig  lol
==================================================
```

In [69]:

```
#remove words with numbers python: https://stackoverflow.com/a/18082370/4084039
sent_0 = re.sub("\S*\d\S*", "", sent_0).strip()
print(sent_0)
```

```
My dogs loves this chicken but its a product from China, so we wont be buying it anymore.  Its ver
y hard to find any chicken products made in the USA but they are out there, but this one isnt.  It
s too bad too because its a good product but I wont take any chances till they know what is going
on with the china imports.
```

In [70]:

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

```
was way to hot for my blood took a bite and did a jig lol
```

In [71]:

```
# https://gist.github.com/sebleier/554280
# we are removing the words from the stop words list: 'no', 'nor', 'not'
# <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', 'ours', 'ourselves', 'you', "y
ou're", "you've",\
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his',
'himself', \
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they', 'them',
'their',\
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll",
'these', 'those', \
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', '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', 'how', 'all', 'any', 'both', 'e
ach', 'few', 'more',\
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', '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', "d
esn't", 'hadn',\
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn'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 [72]:

```
# Combining all the above stundents
from tqdm import tqdm
```

```
preprocessed_reviews = []
# 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.lower() not in stopwords)
    preprocessed_reviews.append(sentance.strip())
```

```
100%|██████████████████████████████████████████████████████████████████████████| 87773/87773
[00:24<00:00, 3558.40it/s]
```

In [73]:

```
preprocessed_reviews[1500]
```

Out[73]:

```
'way hot blood took bite jig lol'
```

In [74]:

```
final ['preprocessed_reviews']= preprocessed_reviews
final.head(5)
```

Out[74]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	Time	Sum
22620	24750	2734888454	A13ISQV0U9GZIC	Sandikaye	1	1	0	1192060800	m
22621	24751	2734888454	A1C298ITT645B6	Hugh G. Pritchard	0	0	1	1195948800	Dog D
70677	76870	B00002N8SM	A19Q006CSFT011	Arlielle	0	0	0	1288396800	on
70676	76869	B00002N8SM	A1FYH4S02BW7FN	wonderer	0	0	0	1290038400	D m
70675	76868	B00002N8SM	AUE8TB5VHS6ZV	eyeofthestorm	0	0	0	1306972800	A

In [75]:

```
preprocessed_summary = []
# tqdm is for printing the status bar
for summary in tqdm(final['Summary'].values):
    summary = re.sub(r"http\S+", "", summary)
    # remove urls from text python: https://stackoverflow.com/a/40823105/4084039
    summary = BeautifulSoup(summary, 'lxml').get_text()
    # https://stackoverflow.com/questions/16206380/python-beautifulsoup-how-to-remove-all-tags-fro
m-an-element
    summary = decontracted(summary)
    summary = re.sub("\S*\d\S*", "", summary).strip() #remove words with numbers python: https://st
ackoverflow.com/a/18082370/4084039
```

```
    summary = re.sub('[^A-Za-z]+', ' ', summary) #remove spacial character:
https://stackoverflow.com/a/5843547/4084039
    # https://gist.github.com/sebleier/554280
    summary = ' '.join(e.lower() for e in summary.split() if e.lower() not in stopwords)
    preprocessed_summary.append(summary.strip())
```

```
100%|██████████████████████████████████████████████████████████████████████████| 87773/87773
[00:16<00:00, 5363.37it/s]
```

In [76]:

```
preprocessed_reviews = [i + ' ' + j for i, j in zip(preprocessed_reviews,preprocessed_summary)]
print(preprocessed_reviews[1500])
```

```
way hot blood took bite jig lol hot stuff
```

FEATURIZATION

BOW

In [77]:

```
Y = final['Score'].values
X = np.array(preprocessed_reviews)
```

In [78]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.train_test_split.html
from sklearn.model_selection import train_test_split

X_train, X_test, y_train, y_test = train_test_split(X, final['Score'], test_size=0.33, shuffle=Fals
e,random_state=0)
X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train,
test_size=0.33,shuffle=False,random_state=0)# this is for time series split
#X_train, X_test, y_train, y_test = train_test_split(X, Y, test_size=0.33) # this is random splitt
ing
#X_train, X_cv, y_train, y_cv = train_test_split(X_train, y_train, test_size=0.33) # this is rando
m splitting


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

print("="*100)

from sklearn.feature_extraction.text import CountVectorizer
vectorizer = CountVectorizer()
vectorizer.fit(X_train) # fit has to happen only on train data

# we use the fitted CountVectorizer to convert the text to vector
X_train_bow = vectorizer.transform(X_train)
X_cv_bow = vectorizer.transform(X_cv)
X_test_bow = vectorizer.transform(X_test)

print("After vectorizations")
print(X_train_bow.shape, y_train.shape)
print(X_cv_bow.shape, y_cv.shape)
print(X_test_bow.shape, y_test.shape)
print("="*100)

print("NOTE: THE NUMBER OF COLUMNS IN EACH OF THE VECTOR WONT BE SAME")
```

```
(39400,) (39400,)
(19407,) (19407,)
(28966,) (28966,)
====================================================================================================
```

```
After vectorizations
(39400, 38503) (39400,)
(19407, 38503) (19407,)
(28966, 38503) (28966,)
==================================================================================================

NOTE: THE NUMBER OF COLUMNS IN EACH OF THE VECTOR WONT BE SAME
```

BI-GRAMS AND N-GRAMS

In [79]:

```
#bi-gram, tri-gram and n-gram

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

# you can choose these numebrs min_df=10, max_features=5000, of your choice
count_vect = CountVectorizer(ngram_range=(1,2), min_df=10, max_features=5000)
final_bigram_counts = count_vect.fit_transform(preprocessed_reviews)
print("the type of count vectorizer ",type(final_bigram_counts))
print("the shape of out text BOW vectorizer ",final_bigram_counts.get_shape())
print("the number of unique words including both unigrams and bigrams ", final_bigram_counts.get_s
hape()[1])
```

```
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer  (87773, 5000)
the number of unique words including both unigrams and bigrams  5000
```

TF-IDF

In [80]:

```
tf_idf_vect = TfidfVectorizer(ngram_range=(1,2), min_df=10)
tf_idf_vect.fit(X_train)
print("some sample features(unique words in the corpus)",tf_idf_vect.get_feature_names()[0:10])
print('='*50)

train_tf_idf = tf_idf_vect.transform(X_train)
cv_tf_idf = tf_idf_vect.transform(X_cv)
test_tf_idf = tf_idf_vect.transform(X_test)
print("the type of count vectorizer ",type(train_tf_idf))
print("the shape of out text TRAIN TFIDF vectorizer ",train_tf_idf.get_shape())
print("the shape of out text CV TFIDF vectorizer ",cv_tf_idf.get_shape())
print("the shape of out text TEST TFIDF vectorizer ",test_tf_idf.get_shape())
print("the number of unique words including both unigrams and bigrams in train ", train_tf_idf.get
_shape()[1])
```

```
some sample features(unique words in the corpus) ['abdominal', 'ability', 'able', 'able buy',
'able drink', 'able eat', 'able enjoy', 'able find', 'able get', 'able give']
==================================================
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TRAIN TFIDF vectorizer  (39400, 24483)
the shape of out text CV TFIDF vectorizer  (19407, 24483)
the shape of out text TEST TFIDF vectorizer  (28966, 24483)
the number of unique words including both unigrams and bigrams in train  24483
```

W2V

In [81]:

```
# Train your own Word2Vec model using your own text corpus
i=0
sent_of_train=[]
for sentance in X_train:
```

```
    sent_of_train.append(sentance.split())
```

In [82]:

```
# Train your own Word2Vec model using your own text corpus
i=0
sent_of_test=[]
for sentance in X_test:
    sent_of_test.append(sentance.split())
```

In [83]:

```
# Train your own Word2Vec model using your own text corpus
i=0
sent_of_cv=[]
for sentance in X_cv:
    sent_of_cv.append(sentance.split())
```

In [84]:

```
# Using Google News Word2Vectors

# in this project we are using a pretrained model by google
# its 3.3G file, once you load this into your memory
# it occupies ~9Gb, so please do this step only if you have >12G of ram
# we will provide a pickle file wich contains a dict ,
# and it contains all our courpus words as keys and  model[word] as values
# To use this code-snippet, download "GoogleNews-vectors-negative300.bin"
# from https://drive.google.com/file/d/0B7XkCwpI5KDYNlNUTTlSS21pQmM/edit
# it's 1.9GB in size.


# http://kavita-ganesan.com/gensim-word2vec-tutorial-starter-code/#.W17SRFAzZPY
# you can comment this whole cell
# or change these varible according to your need

is_your_ram_gt_16g=False
want_to_use_google_w2v = False
want_to_train_w2v = True

if want_to_train_w2v:
    # min_count = 5 considers only words that occured atleast 5 times
    w2v_model=Word2Vec(sent_of_train,min_count=5,size=50, workers=4)
    print(w2v_model.wv.most_similar('great'))
    print('='*50)
    print(w2v_model.wv.most_similar('worst'))

elif want_to_use_google_w2v and is_your_ram_gt_16g:
    if os.path.isfile('GoogleNews-vectors-negative300.bin'):
        w2v_model=KeyedVectors.load_word2vec_format('GoogleNews-vectors-negative300.bin', binary=Tr
ue)
        print(w2v_model.wv.most_similar('great'))
        print(w2v_model.wv.most_similar('worst'))
    else:
        print("you don't have google's word2vec file, keep want_to_train_w2v = True, to train your
own w2v ")
```

```
[('good', 0.8082051873207092), ('fantastic', 0.8015952706336975), ('awesome', 0.7967922687530518),
('excellent', 0.7895177602767944), ('terrific', 0.7760144472122192), ('wonderful',
0.7619636058807373), ('perfect', 0.7317036390304565), ('fabulous', 0.6847324371337891),
('amazing', 0.6817454099655151), ('nice', 0.6722251176834106)]
==================================================
[('best', 0.6968291997909546), ('experienced', 0.6896380186080933), ('greatest',
0.6842389106750488), ('softest', 0.6445863246917725), ('closest', 0.6421364545822144),
('disgusting', 0.6316479444503784), ('nastiest', 0.6189910173416138), ('tastiest',
0.6181024312973022), ('overrated', 0.6122164726257324), ('tasted', 0.6033949851989746)]
```

In [85]:

```
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  12321
sample words  ['dogs', 'loves', 'chicken', 'product', 'china', 'wont', 'buying', 'anymore',
'hard', 'find', 'products', 'made', 'usa', 'one', 'isnt', 'bad', 'good', 'take', 'chances',
'till', 'know', 'going', 'imports', 'love', 'saw', 'pet', 'store', 'tag', 'attached', 'regarding',
'satisfied', 'safe', 'dog', 'lover', 'infestation', 'literally', 'everywhere', 'flying', 'around',
'kitchen', 'bought', 'hoping', 'least', 'get', 'rid', 'weeks', 'fly', 'stuck', 'buggers', 'success
']
```

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

[4.4.1.1] Avg W2v

In [86]:

```
# average Word2Vec
# compute average word2vec for each review.
sent_vectors_cv= []; # the avg-w2v for each sentence/review is stored in this list
for sent in tqdm(sent_of_cv): # for each review/sentence
    sent_vec_cv = np.zeros(50) # as word vectors are of zero length 50, you 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/review
    for word in sent: # for each word in a review/sentence
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec_cv += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec_cv /= cnt_words
    sent_vectors_cv.append(sent_vec_cv)
print(len(sent_vectors_cv))
print(len(sent_vectors_cv[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 19407/19407 [00:
30<00:00, 637.24it/s]
```

```
19407
50
```

In [87]:

```
# average Word2Vec
# compute average word2vec for each review.
sent_vectors_train= []; # the avg-w2v for each sentence/review is stored in this list
for sent in tqdm(sent_of_train): # for each review/sentence
    sent_vec_train = np.zeros(50) # as word vectors are of zero length 50, you 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/review
    for word in sent: # for each word in a review/sentence
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec_train += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec_train /= cnt_words
    sent_vectors_train.append(sent_vec_train)
print(len(sent_vectors_train))
print(len(sent_vectors_train[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████| 39400/39400 [00:
55<00:00, 713.75it/s]
```

```
39400
50
```

In [88]:

```
# average Word2Vec
# compute average word2vec for each review.
```

```
# compute average word2vec for each review.
sent_vectors_test= []; # the avg-w2v for each sentence/review is stored in this list
for sent in tqdm(sent_of_test): # for each review/sentence
    sent_vec_test = np.zeros(50) # as word vectors are of zero length 50, you 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/review
    for word in sent: # for each word in a review/sentence
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec_test += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec_test /= cnt_words
    sent_vectors_test.append(sent_vec_test)
print(len(sent_vectors_test))
print(len(sent_vectors_test[0]))
```

```
100%|██████████████████████████████████████████████████████████████████████████████| 28966/28966 [00:
43<00:00, 665.24it/s]
```

```
28966
50
```

[5] Assignment 4: Apply Naive Bayes

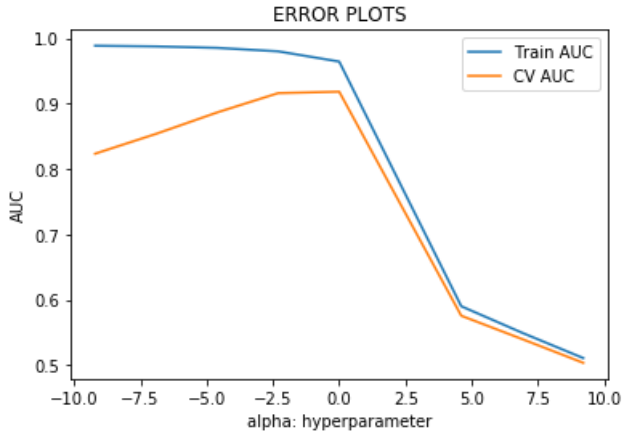
1. **Apply Multinomial NaiveBayes on these feature sets**
   - SET 1:Review text, preprocessed one converted into vectors using (BOW)
   - SET 2:Review text, preprocessed one converted into vectors using (TFIDF)
2. **The hyper paramter tuning(find best Alpha)**
   - Find the best hyper parameter which will give the maximum AUC value
   - Consider a wide range of alpha values for hyperparameter tuning, start as low as 0.00001
   - 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
3. **Feature importance**
   - Find the top 10 features of positive class and top 10 features of negative class for both feature sets Set 1 and Set 2 using values of `feature_log_prob_` parameter of MultinomialNB and print their corresponding feature names
4. **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.
5. **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. Here on X-axis you will have alpha values, since they have a wide range, just to represent those alpha values on the graph, apply log function on those alpha values.
   - 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.
6. **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

Applying Multinomial Naive Bayes

[5.1] Applying Naive Bayes on BOW, SET 1

In [89]:

```
from sklearn.naive_bayes import MultinomialNB
from math import log
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.

y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, confidence values, or no
n-thresholded measure of
decisions (as returned by "decision_function" on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with greater label.

"""

train_auc = []
cv_auc = []
alpha = [0.0001, 0.001, 0.01, 0.1, 1, 100, 1000, 10000]
logalpha = [log(y) for y in alpha]
for i in alpha:
    clf = MultinomialNB(alpha=i)
    clf.fit(X_train_bow, y_train)
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs
    y_train_pred =  clf.predict_log_proba(X_train_bow)[:,1]
    y_cv_pred =  clf.predict_log_proba(X_cv_bow)[:,1]

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

plt.plot(logalpha, train_auc, label='Train AUC')
plt.plot(logalpha, cv_auc, label='CV AUC')
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.show()
```

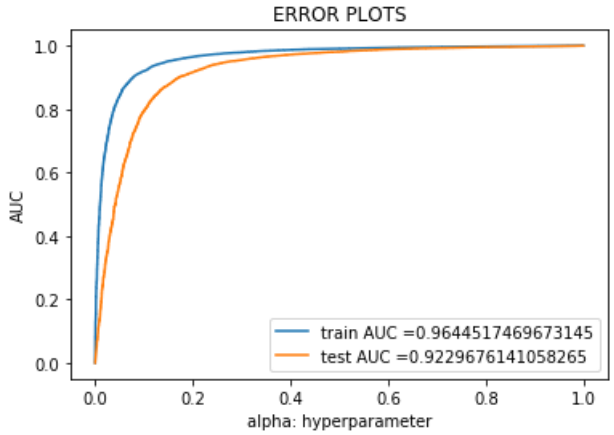


In [90]:

```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc

opt_auc = alpha[cv_auc.index(max(cv_auc))]
print(opt_auc)

clf = MultinomialNB(alpha=opt_auc,class_prior=[0.5,0.5],fit_prior=True)
clf.fit(X_train_bow, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
```

```
class
# not the predicted outputs

train_fpr, train_tpr, thresholds = roc_curve(y_train, clf.predict_log_proba(X_train_bow)[:,1])
test_fpr, test_tpr, thresholds = roc_curve(y_test, clf.predict_log_proba(X_test_bow)[:,1])

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_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("ERROR PLOTS")
plt.show()

print("="*100)

from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, clf.predict(X_train_bow)))
print("Test confusion matrix")
print(confusion_matrix(y_test, clf.predict(X_test_bow)))

# Summarizing the values
bow_train= train_auc
bow_test = cv_auc

BOW_test=max(bow_test)
```

```
1
```

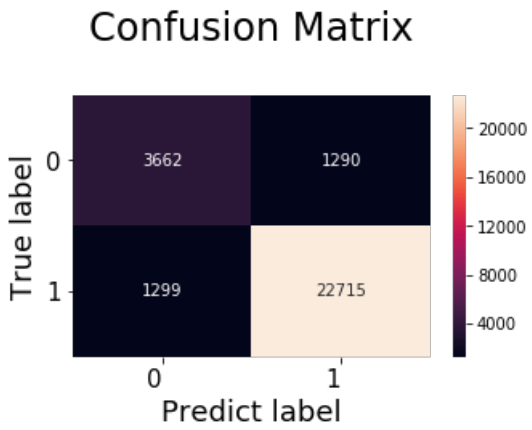



```
==========================================================================================

Train confusion matrix
[[ 5277   897]
 [ 1686 31540]]
Test confusion matrix
[[ 3662  1290]
 [ 1299 22715]]
```

In [91]:

```
# CONFUSION MATRIX

cm = confusion_matrix(y_train, clf.predict(X_train_bow))
cm = confusion_matrix(y_test, clf.predict(X_test_bow))
tn, fp, fn, tp = cm.ravel()

# Code for drawing seaborn heatmaps
class_names = ['0','1']
df_heatmap = pd.DataFrame(cm, index=class_names, columns=class_names )
fig = plt.figure(figsize=(5,3))
heatmap = sns.heatmap(df_heatmap, annot=True, fmt="d")
# Setting tick labels for heatmap
heatmap.yaxis.set_ticklabels(heatmap.yaxis.get_ticklabels(), rotation=0, ha='right', fontsize=15)
heatmap.xaxis.set_ticklabels(heatmap.xaxis.get_ticklabels(), rotation=0, ha='right', fontsize=15)
plt.ylabel('True label',size=18)
```

```
plt.xlabel("Predict label",size=18)
plt.title("Confusion Matrix\n",size=24)
plt.show()
```



[5.1.1] Top 10 important features of positive class from SET 1

In [92]:

```
pos_sorted = clf.feature_log_prob_[1, :].argsort()
print(np.take(vectorizer.get_feature_names(), pos_sorted[-10:]))
```

```
['food' 'product' 'taste' 'one' 'love' 'tea' 'like' 'good' 'great' 'not']
```

[5.1.2] Top 10 important features of negative class from SET 1

In [93]:

```
neg_sorted = clf.feature_log_prob_[0, :].argsort()
print(np.take(vectorizer.get_feature_names(), neg_sorted[-10:]))
```

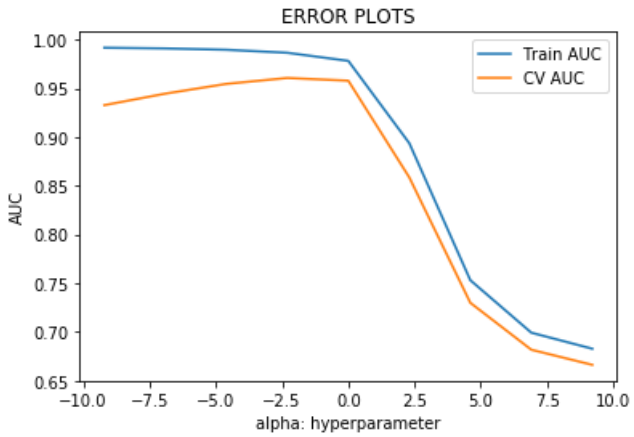
```
['tea' 'no' 'food' 'good' 'one' 'would' 'taste' 'product' 'like' 'not']
```

[5.2] Applying Naive Bayes on TFIDF, SET 2

In [94]:

```
from math import log
from sklearn.metrics import roc_auc_score
import matplotlib.pyplot as plt
"""
y_true : array, shape = [n_samples] or [n_samples, n_classes]
True binary labels or binary label indicators.

y_score : array, shape = [n_samples] or [n_samples, n_classes]
Target scores, can either be probability estimates of the positive class, confidence values, or no
n-thresholded measure of
decisions (as returned by "decision_function" on some classifiers).
For binary y_true, y_score is supposed to be the score of the class with greater label.

"""

train_auc = []
cv_auc = []
alpha = [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
logalpha = [log(y) for y in alpha]
for i in alpha:
    clf = MultinomialNB(alpha=i,class_prior=[0.5,0.5],fit_prior=True)
    clf.fit(train_tf_idf, y_train)
    # roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the posi
tive class
    # not the predicted outputs
```

```
    y_train_pred =  clf.predict_log_proba(train_tf_idf)[:,1]
    y_cv_pred =  clf.predict_log_proba(cv_tf_idf)[:,1]

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

plt.plot(logalpha, train_auc, label='Train AUC')
plt.plot(logalpha, cv_auc, label='CV AUC')
plt.legend()
plt.xlabel("alpha: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.show()
```

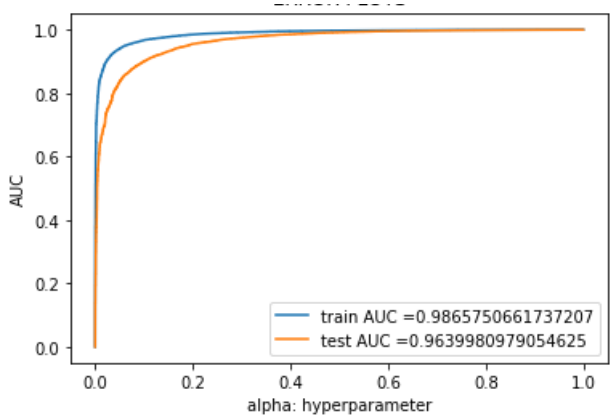


In [95]:

```
# https://scikit-
learn.org/stable/modules/generated/sklearn.metrics.roc_curve.html#sklearn.metrics.roc_curve
from sklearn.metrics import roc_curve, auc

best_auc = alpha[cv_auc.index(max(cv_auc))]
print(best_auc)

clf = MultinomialNB(alpha=best_auc)
clf.fit(train_tf_idf, y_train)
# roc_auc_score(y_true, y_score) the 2nd parameter should be probability estimates of the positive
class
# not the predicted outputs

train_fpr, train_tpr, thresholds = roc_curve(y_train, clf.predict_log_proba(train_tf_idf)[:,1])
test_fpr, test_tpr, thresholds = roc_curve(y_test, clf.predict_log_proba(test_tf_idf)[:,1])

plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, train_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("ERROR PLOTS")
plt.show()

print("="*100)

from sklearn.metrics import confusion_matrix
print("Train confusion matrix")
print(confusion_matrix(y_train, clf.predict(train_tf_idf)))
print("Test confusion matrix")
print(confusion_matrix(y_test, clf.predict(test_tf_idf)))

# Summarizing the values
tfidf_train= train_auc
tfidf_test = cv_auc

TFIDF_test= max(tfidf_test)
```

```
0.1
```

ERROR PLOTS



==========

```
Train confusion matrix
[[ 4416  1758]
 [  297 32929]]
Test confusion matrix
[[ 2689  2263]
 [  248 23766]]
```

In [96]:

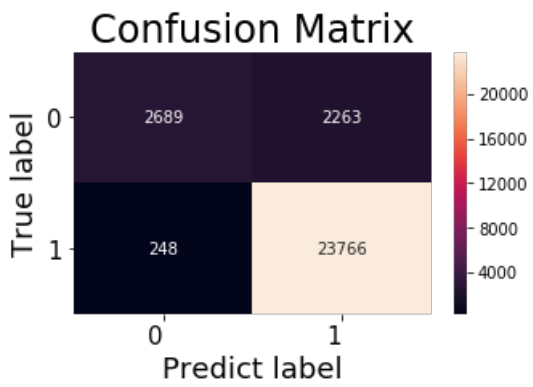
```
#Confusion Matrix

cm = confusion_matrix(y_train, clf.predict(train_tf_idf))
cm = confusion_matrix(y_test, clf.predict(test_tf_idf))
tn, fp, fn, tp = cm.ravel()
# https://stackoverflow.com/questions/35572000/how-can-i-plot-a-confusion-matrix
```

In [97]:

```
# Code for drawing seaborn heatmaps
class_names = ['0','1']
df_heatmap = pd.DataFrame(cm, index=class_names, columns=class_names )
fig = plt.figure(figsize=(5,3))
heatmap = sns.heatmap(df_heatmap, annot=True, fmt="d")
# Setting tick labels for heatmap
heatmap.yaxis.set_ticklabels(heatmap.yaxis.get_ticklabels(), rotation=0, ha='right', fontsize=15)
heatmap.xaxis.set_ticklabels(heatmap.xaxis.get_ticklabels(), rotation=0, ha='right', fontsize=15)
plt.ylabel('True label',size=18)
plt.xlabel('Predict label',size=18)
plt.title("Confusion Matrix",size=24)
```

Out[97]:

```
Text(0.5, 1.0, 'Confusion Matrix')
```



[5.2.1] Top 10 important features of positive class from SET 2

In [98]:

```
pos_sorted = clf.feature_log_prob_[1, :].argsort()
print(np.take(tf_idf_vect.get_feature_names(), pos_sorted[-10:]))
```

```
['one' 'taste' 'best' 'product' 'like' 'love' 'good' 'tea' 'great' 'not']
```

[5.2.2] Top 10 important features of negative class from SET 2

In [99]:

```
neg_sorted = clf.feature_log_prob_[0, :].argsort()
print(np.take(tf_idf_vect.get_feature_names(), neg_sorted[-10:]))
```

```
['good' 'food' 'no' 'tea' 'one' 'would' 'taste' 'product' 'like' 'not']
```

[6] Conclusions

In [100]:

```
from prettytable import PrettyTable

x = PrettyTable()

x.field_names = ["S.NO","MODEL", "ALPHA"]

x.add_row(["1","BAG OF WORDS",BOW_test])
x.add_row(["2","TFIDF",TFIDF_test])

# Printing the Table
print(x)
```

```
+------+--------------+--------------------+
| S.NO |    MODEL     |       ALPHA        |
+------+--------------+--------------------+
|  1   | BAG OF WORDS | 0.9183677387171265 |
|  2   |    TFIDF     | 0.9606901841964506 |
+------+--------------+--------------------+
```

[7] Summary

1. The values of the hyperparameter in Naive Bayes is better than that of KNN.
2. The AUC values of Naive Bayes are more when compared to KNN.
3. The hyperparameter(alpha) in Naive Bayes is higher in the TFIDF model.