In [0]:
```
%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
from sklearn import linear_model
from sklearn.calibration import CalibratedClassifierCV
```

In [2]:
```
#mounting the dataset from drive
from google.colab import drive
drive.mount('/content/gdrive')

#connecting to sqlite db
con = sqlite3.connect('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 p
# 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 LI
# for tsne assignment you can take 5k data points

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

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

```
Go to this URL in a browser: https://accounts.google.com/o/oauth2/auth?client_i
d=947318989803-6bn6qk8qdgf4n4g3pfee6491hc0brc4i.apps.googleusercontent.com&redi
rect_uri=urn%3Aietf%3Awg%3Aoauth%3A2.0%3Aoob&scope=email%20https%3A%2F%2Fwww.go
ogleapis.com%2Fauth%2Fdocs.test%20https%3A%2F%2Fwww.googleapis.com%2Fauth%2Fdri
ve%20https%3A%2F%2Fwww.googleapis.com%2Fauth%2Fdrive.photos.readonly%20https%3
A%2F%2Fwww.googleapis.com%2Fauth%2Fpeopleapi.readonly&response_type=code (http
s://accounts.google.com/o/oauth2/auth?client_id=947318989803-6bn6qk8qdgf4n4g3pf
ee6491hc0brc4i.apps.googleusercontent.com&redirect_uri=urn%3Aietf%3Awg%3Aoauth%
3A2.0%3Aoob&scope=email%20https%3A%2F%2Fwww.googleapis.com%2Fauth%2Fdocs.test%2
0https%3A%2F%2Fwww.googleapis.com%2Fauth%2Fdrive%20https%3A%2F%2Fwww.googleapi
s.com%2Fauth%2Fdrive.photos.readonly%20https%3A%2F%2Fwww.googleapis.com%2Fauth%
2Fpeopleapi.readonly&response_type=code)

Enter your authorization code:
..........
Mounted at /content/gdrive
```

In [0]:
```
display = pd.read_sql_query("""
SELECT UserId, ProductId, ProfileName, Time, Score, Text, COUNT(*)
FROM Reviews
GROUP BY UserId
HAVING COUNT(*)>1
""", con)
```

In [0]:
```
print(display.shape)
display.head()
```

```
(80668, 7)
```

Out[4]:

	UserId	ProductId	ProfileName	Time	Score	Text	COUNT
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 [27]:
```
# Removing duplicate reviews
final=filtered_data.drop_duplicates(subset={"UserId","ProfileName","Time","Text"}
print(final.shape)
```

```
(100000, 13)
```

In [28]:
```
(final['Id'].size*1.0)/(filtered_data['Id'].size*1.0)*100
```

Out[28]:
```
100.0
```

In [0]:
```
final=final[final.HelpfulnessNumerator<=final.HelpfulnessDenominator]
```

In [30]:
```
#Before starting the next phase of preprocessing lets see the number of entries le
print(final.shape)

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

```
(100000, 13)
```

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

In [31]:
```
final["cleanReview"] = final["Summary"].map(str) + ". " + final["Text"]
final['cleanReview'].head()
```

Out[31]:
```
117924    EVERY book is educational. this witty little b...
117901    This whole series is great way to spend time w...
298792    Entertainingl Funny!. Beetlejuice is a well wr...
169281    A modern day fairy tale. A twist of rumplestis...
298791    FANTASTIC!. Beetlejuice is an excellent and fu...
Name: cleanReview, dtype: object
```

In [32]:
```
final['lengthOfReview'] = final['cleanReview'].str.split().str.len()
final['lengthOfReview'].head()
```

Out[32]:
```
117924    78
117901    90
298792    31
169281    41
298791    44
Name: lengthOfReview, dtype: int64
```

In [0]:
```
#remove urls from text python
from tqdm import tqdm
lst = []
removed_urls_list = []
for text in tqdm(final['Text']):
  removed_urls_text = re.sub(r"http\S+", "", text)
  lst.append(removed_urls_text)
```

```
100%|██████████| 364171/364171 [00:01<00:00, 313040.89it/s]
```

In [0]:
```
#remove urls from text python
removed_urls_list = []
for text in tqdm(lst):
  removed_urls_text = re.sub(r"http\S+", "", text)
  removed_urls_list.append(removed_urls_text)
```

```
100%|██████████| 364171/364171 [00:01<00:00, 343430.96it/s]
```

In [0]:
```
from bs4 import BeautifulSoup
text_lst = []
for text in tqdm(removed_urls_list):
  soup = BeautifulSoup(text, 'lxml')
  text = soup.get_text()
  text_lst.append(text)
# print(text)
# print("="*50)
```

```
100%|██████████████████████████████████████████████████████████████████████| 364171/364171 [02:16<00:00, 2662.25it/s]
```

In [0]:
```
print(len(final['Text']))
```

```
364171
```

In [0]:
```
# 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 [0]:
```
decat_lst = []
for decat_text in tqdm(text_lst):
  text = decontracted(decat_text)
  decat_lst.append(text)
```

```
100%|██████████████████████████████████████████████████████████████████████| 364171/364171 [00:06<00:00, 53616.87it/s]
```

In [0]:
```
strip_list = []
for to_strip in tqdm(decat_lst):
  text = re.sub("\S*\d\S*", "", to_strip).strip()
  strip_list.append(text)
```

```
100%|██████████████████████████████████████████████████████████████████████| 364171/364171 [00:30<00:00, 11914.41it/s]
```

In [0]:
```
spatial_list = []
for to_spatial in tqdm(strip_list):
  text = re.sub('[^A-Za-z0-9]+', ' ', to_spatial)
  spatial_list.append(text)
```

```
100%|████████████████████████████████████████████████████████████
████████████████████| 364171/364171 [00:20<00:00, 18059.44it/s]
```

In [0]:
```
stopwords= set(['br', 'the', 'i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'our
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', '
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itsel
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because'
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'th
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all'
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than',
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "di
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma',
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn'
            'won', "won't", 'wouldn', "wouldn't"])
```

In [0]:
```
# Combining all the above stundents
preprocessed_reviews = []
# tqdm is for printing the status bar
for sentance in tqdm(spatial_list):
    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 s
    preprocessed_reviews.append(sentance.strip())
```

```
100%|████████████████████████████████████████████████████████████
████████████████████| 364171/364171 [03:37<00:00, 1671.64it/s]
```

In [0]:
```
print(len(preprocessed_reviews))
preprocessed_reviews[-1]
```

```
364171
```

Out[21]:
```
'satisfied product advertised use cereal raw vinegar general sweetner'
```

In [0]:
```
final['Preprocessed_text'] = preprocessed_reviews
```

In [0]:
```
print(len(final))
final.tail(5)
```

```
364171
```

Out[23]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	He
525809	568450	B001EO7N10	A28KG5XORO54AY	Lettie D. Carter	0	0
525810	568451	B003S1WTCU	A3I8AFVPEE8KI5	R. Sawyer	0	0
525811	568452	B004I613EE	A121AA1GQV751Z	pksd "pk_007"	2	2
525812	568453	B004I613EE	A3IBEVCTXKNOH	Kathy A. Welch "katwel"	1	1
525813	568454	B001LR2CU2	A3LGQPJCZVL9UC	srfell17	0	0

In [0]:
```
dir_path = os.getcwd()
conn = sqlite3.connect(os.path.join(dir_path, '/content/gdrive/My Drive/Colab Not
# final.to_sql('Reviews', conn, if_exists='replace', index=False)
```

In [4]:
```
review_3 = pd.read_sql_query(""" SELECT count(*) FROM Reviews""", conn)
print(review_3)
```

```
   count(*)
0    364171
```

In [0]:
```
filtered_data = pd.read_sql_query(""" SELECT * FROM Reviews""", conn)
```

In [6]:
```
filtered_data.shape
```

Out[6]:
```
(364171, 13)
```

In [0]:
```
filtered_data["Time"] = pd.to_datetime(filtered_data["Time"], unit = "s")
filtered_data = filtered_data.sort_values(by = "Time")
```

In [8]:
```
filtered_data.head(5)
```

Out[8]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	Hel
117924	150524	0006641040	ACITT7DI6IDDL	shari zychinski	0	0
117901	150501	0006641040	AJ46FKXOVC7NR	Nicholas A Mesiano	2	2
298792	451856	B00004CXX9	AIUWLEQ1ADEG5	Elizabeth Medina	0	0
169281	230285	B00004RYGX	A344SMIA5JECGM	Vincent P. Ross	1	2
298791	451855	B00004CXX9	AJH6LUC1UT1ON	The Phantom of the Opera	0	0

In [9]:
```
print(len(filtered_data))
filtered_data.info()
filtered_data = filtered_data.head(100000)
print(len(filtered_data))
```

```
364171
<class 'pandas.core.frame.DataFrame'>
Int64Index: 364171 entries, 117924 to 107253
Data columns (total 13 columns):
Id                      364171 non-null int64
ProductId               364171 non-null object
UserId                  364171 non-null object
ProfileName             364171 non-null object
HelpfulnessNumerator    364171 non-null int64
HelpfulnessDenominator  364171 non-null int64
Score                   364171 non-null int64
Time                    364171 non-null datetime64[ns]
Summary                 364171 non-null object
Text                    364171 non-null object
cleanReview             364171 non-null object
lengthOfReview          364171 non-null int64
Preprocessed_text       364171 non-null object
dtypes: datetime64[ns](1), int64(5), object(7)
memory usage: 38.9+ MB
100000
```

In [10]:
```
filtered_data['Score'].value_counts()
```

Out[10]:
```
1    87729
0    12271
Name: Score, dtype: int64
```

In [11]:
```
X = filtered_data["cleanReview"]
print(print("shape of X:", X.head(5)))
y = filtered_data["Score"]
print("shape of y:", y.head(5))
X_len = filtered_data['lengthOfReview']
```

```
shape of X: 117924    EVERY book is educational. this witty little b...
117901    This whole series is great way to spend time w...
298792    Entertainingl Funny!. Beetlejuice is a well wr...
169281    A modern day fairy tale. A twist of rumplestis...
298791    FANTASTIC!. Beetlejuice is an excellent and fu...
Name: cleanReview, dtype: object
None
shape of y: 117924    1
117901    1
298792    1
169281    1
298791    1
Name: Score, dtype: int64
```

In [12]:
```
len(filtered_data['lengthOfReview'])
```

Out[12]:
```
100000
```

In [0]:
```
X_train = X[0:60000]
Y_train = y[0:60000]
X_val = X[60000:80000]
Y_val = y[60000:80000]
X_test = X[80000:100000]
Y_test = y[80000:100000]
```

In [0]:
```
print(len(X_train), len(X_test), len(X_val))
print(len(Y_train), len(Y_test), len(Y_val))
```

```
60000 20000 20000
60000 20000 20000
```

[4.1] BAG OF WORDS

In [0]:
```
from sklearn.feature_extraction.text import CountVectorizer

count_vect = CountVectorizer()
X_train_vect = count_vect.fit_transform(X_train)
X_test_vect = count_vect.transform(X_test)
X_val_vect = count_vect.transform(X_val)
feature_names = count_vect.get_feature_names()
# BoW_dict = {'X_train_vect':X_train_vect, 'X_test_vect': X_test_vect, 'X_val_vec
print(X_train_vect.shape)
# print(feature_names)
```

```
(60000, 48270)
```

In [0]:
```
X_train_vect.shape
```

Out[39]:
```
(60000, 48270)
```

In [0]:
```
len(final['lengthOfReview'])
```

Out[40]:
```
364171
```

In [0]:
```
from scipy.sparse import hstack
# len_review = final['lengthOfReview'].to_sparse()
concat_data = hstack((X_train_vect,np.array(final['lengthOfReview'][0:60000])[:,N
concat_data_val = hstack((X_val_vect,np.array(final['lengthOfReview'][60000:80000
concat_data_test = hstack((X_test_vect,np.array(final['lengthOfReview'][80000:100
```

In [0]:
```
print(concat_data.shape)
print(concat_data_val.shape)
print(concat_data_test.shape)
```

```
(60000, 48271)
(20000, 48271)
(20000, 48271)
```

In [0]:
```
print(len(feature_names))
```

```
48270
```

In [0]:
```
BoW_dict = {'X_train_vect':concat_data, 'X_test_vect': concat_data_test, 'X_val_v
print(BoW_dict['X_train_vect'].shape)
```

```
(60000, 48271)
```

In [0]:
```
import pickle
with open('BoW.pkl', 'wb') as handle:
    pickle.dump(BoW_dict, handle, protocol=pickle.HIGHEST_PROTOCOL)
```

[4.3] TF-IDF

In [0]:
```
tf_idf_vect = TfidfVectorizer(ngram_range=(1,2), min_df=10)
train_tf_idf = tf_idf_vect.fit_transform(X_train)
cv_tf_idf = tf_idf_vect.transform(X_val)
test_tf_idf = tf_idf_vect.transform(X_test)

print("the shape of out text TFIDF vectorizer ",train_tf_idf.get_shape())
print("the type of count vectorizer ",type(train_tf_idf))
print("the number of unique words including both unigrams and bigrams ", train_tf_
```

```
the shape of out text TFIDF vectorizer  (60000, 61750)
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the number of unique words including both unigrams and bigrams  61750
```

In [0]:
```
tfidf_concat_data_train = hstack((train_tf_idf,np.array(final['lengthOfReview'][0
tfidf_concat_data_val = hstack((cv_tf_idf,np.array(final['lengthOfReview'][60000:
tfidf_concat_data_test = hstack((test_tf_idf,np.array(final['lengthOfReview'][800
```

In [0]:
```
tf_idf_dict = {'train_tf_idf': tfidf_concat_data_train, 'cv_tf_idf': tfidf_concat_
```

In [0]:
```
import pickle
with open('tf_idf.pkl', 'wb') as handle:
    pickle.dump(tf_idf_dict, handle, protocol=pickle.HIGHEST_PROTOCOL)
```

[4.4] Word2Vec

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

In [0]:
```
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(list_of_sen,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-negative3
        print(w2v_model.wv.most_similar('great'))
        print(w2v_model.wv.most_similar('worst'))
    else:
        print("you don't have gogole's word2vec file, keep want_to_train_w2v = Tr
```

```
[('wonderful', 0.8974846005439758), ('fantastic', 0.869934618473053), ('good',
0.8506890535354614), ('terrific', 0.8287807703018188), ('perfect', 0.7907924056
053162), ('fabulous', 0.7832920551300049), ('nice', 0.7617159485816956), ('deli
cious', 0.7552177309989929), ('excellent', 0.7302758097648621), ('great,', 0.71
27977609634399)]
==================================================
[('best', 0.8477296233177185), ('greatest', 0.7988674640655518), ('tastiest',
0.7597992420196533), ('closest', 0.7456486225128174), ('BEST', 0.73299777507781
98), ('best-tasting', 0.7289355993270874), ('best.', 0.6994760036468506), ('Bes
t', 0.6785157918930054), ('smoothest', 0.6748092174530029), ('coolest', 0.66516
92390441895)]
```

In [0]:
```
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  32552
sample words  ['prunes', 'Good', 'business.', 'pipes', 'couple,', 'crepe', 'Sod
a,', 'Huckleberry', 'favorites!', 'pleasent', 'marvelous.', '/>Last', 'marriag
e.', 'missing.', 'courtesy', 'pretzels.', 'chooses', '/>Made', 'heated', 'Primu
la', 'flossies', 'bones.', 'PowerGel', '"In', 'sparingly', 'since', 'Upon', 'gi
rl.', 'franks', 'oil)', 'cups', 'full-time', '15%', 'had.<br', 'originally', 'c
ertainly', 'enjoying', 'freeze-dried', '1st', "O'clock", 'pronounced.', '64',
'"Natural', 'trance', 'mainly', 'topper', '"big', 'figure.', 'Wabash', 'sayin
g']
```

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

[4.4.1.1] Avg W2v

In [0]:
```
print(X_train[117924])
print(len(X_val))
print(len(X_test))
```

```
EVERY book is educational. this witty little book makes my son laugh at loud. i
recite it in the car as we're driving along and he always can sing the refrain.
he's learned about whales, India, drooping roses:  i love all the new words thi
s book  introduces and the silliness of it all.  this is a classic book i am  w
illing to bet my son will STILL be able to recite from memory when he is  in co
llege
20000
20000
```

In [0]:
```
# average Word2Vec
# compute average word2vec for each review.
def avg_w2vec(sentences_received):
    sent_vectors = []; # the avg-w2v for each sentence/review is stored in this l
    for sent in tqdm(sentences_received): # for each review/sentence
        sent_vec = np.zeros(50) # as word vectors are of zero length 50, you migh
        cnt_words =0; # num of words with a valid vector in the sentence/review
        for word in sent: # for each word in a review/sentence
            if word in w2v_words:
                vec = w2v_model.wv[word]
                sent_vec += vec
                cnt_words += 1
        if cnt_words != 0:
            sent_vec /= cnt_words
        sent_vectors.append(sent_vec)

    print(len(sent_vectors))
    print(len(sent_vectors[0]))
    return sent_vectors
```

In [0]:
```
print(len([sent.split() for sent in X_test]))
```

```
20000
```

In [0]:
```
avg_w2v_train = avg_w2vec([sent.split() for sent in X_train])
avg_w2v_cv = avg_w2vec([sent.split() for sent in X_val])
avg_w2v_test = avg_w2vec([sent.split() for sent in X_test])
```

```
100%|████████████████████████████████████████████████████████████████
████████████████████████| 60000/60000 [1:26:58<00:00, 11.50it/s]

60000
50

100%|████████████████████████████████████████████████████████████████
████████████████████████| 20000/20000 [30:10<00:00, 11.05it/s]

20000
50

100%|████████████████████████████████████████████████████████████████
████████████████████████| 20000/20000 [26:46<00:00, 12.45it/s]

20000
50
```

In [0]:
```
Avg_w2v_dict = {'X_train_avgw2v':avg_w2v_train, 'Y_train_avgw2v': Y_train,
                      'X_val_avgw2v': avg_w2v_cv, 'Y_val_avgw2v': Y_val,
                     'X_test_avgw2v': avg_w2v_test, 'Y_test_avgw2v': Y_test}
```

In [0]:
```
import pickle
with open('avg_w2v.pkl', 'wb') as handle:
    pickle.dump(Avg_w2v_dict, handle, protocol=pickle.HIGHEST_PROTOCOL)
```

[4.4.1.2] TFIDF weighted W2v

In [0]:
```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
model = TfidfVectorizer()
tf_idf_matrix = model.fit_transform(X_train)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(model.get_feature_names(), list(model.idf_)))
```

In [0]:
```
# TF-IDF weighted Word2Vec
tfidf_feat = model.get_feature_names() # tfidf words/col-names
# final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = t

def tfidf_w2v(sentences_received):
    tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored i
    row=0;
    for sent in tqdm(sentences_received): # 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.append(sent_vec)
        row += 1

    return tfidf_sent_vectors
```

In [0]:
```
tfidf_w2v_train = tfidf_w2v([sent.split() for sent in X_train])
tfidf_w2v_cv = tfidf_w2v([sent.split() for sent in X_val])
tfidf_w2v_test = tfidf_w2v([sent.split() for sent in X_test])
```

In [0]:
```
tfidf_w2v_dict = {'X_train_tfidfw2v':tfidf_w2v_train, 'Y_train_tfidfw2v': Y_train
                      'X_val_tfidfw2v': tfidf_w2v_cv, 'Y_val_tfidfw2v': Y_val,
                     'X_test_tfidfw2v': tfidf_w2v_test, 'Y_test_tfidfw2v': Y_test}
```

In [0]:
```
with open('tfidf_w2v.pkl', 'wb') as handle:
    pickle.dump(tfidf_w2v_dict, handle, protocol=pickle.HIGHEST_PROTOCOL)
```

SVM on BoW

[5.1] Linear SVM

In [0]:
```
import pickle
with open(r"BoW.pkl", "rb") as input_file:
    BoW_dict = pickle.load(input_file)
```

With L1 Regularizer

In [0]:
```
#Applying Logistic Regression with L1 regularization on BOW
from sklearn.linear_model import LogisticRegression
from tqdm import tqdm

bow_svm_train_score_list = []
bow_svm_val_score_list = []
for a_value in tqdm([0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 1000]):
    bow_clf = linear_model.SGDClassifier(loss='hinge', penalty='l1', alpha=a_valu
    bow_clf.fit(BoW_dict['X_train_vect'],Y_train)

    bow_clf_train_score = bow_clf.score(BoW_dict['X_train_vect'], Y_train)
    bow_svm_train_score_list.append(bow_clf_train_score)
    bow_clf_val_score = bow_clf.score(BoW_dict['X_val_vect'], Y_val)
    bow_svm_val_score_list.append(bow_clf_val_score)

c_all = [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
bow_train_score = dict(zip(c_all, bow_svm_train_score_list))
bow_val_score = dict(zip(c_all, bow_svm_val_score_list))
print(bow_train_score)
print(bow_val_score)
```

```
100%|██████████████████████████████████████████████████████████████████████| 9/9 [00:03<0
0:00,  2.84it/s]

{0.1: 0.8858166666666667, 1: 0.8858166666666667, 100: 0.8858166666666667, 1000
0: 0.8858166666666667, 1000: 0.8858166666666667, 0.0001: 0.93200000000000005, 1
0: 0.8858166666666667, 0.01: 0.88591666666666669, 0.001: 0.91011666666666668}
{0.1: 0.86280000000000001, 1: 0.86280000000000001, 100: 0.86280000000000001, 10
000: 0.86280000000000001, 1000: 0.86280000000000001, 0.0001: 0.92135, 10: 0.862
80000000000001, 0.01: 0.86294999999999999, 0.001: 0.90144999999999997}
```

With L2 Regularizer

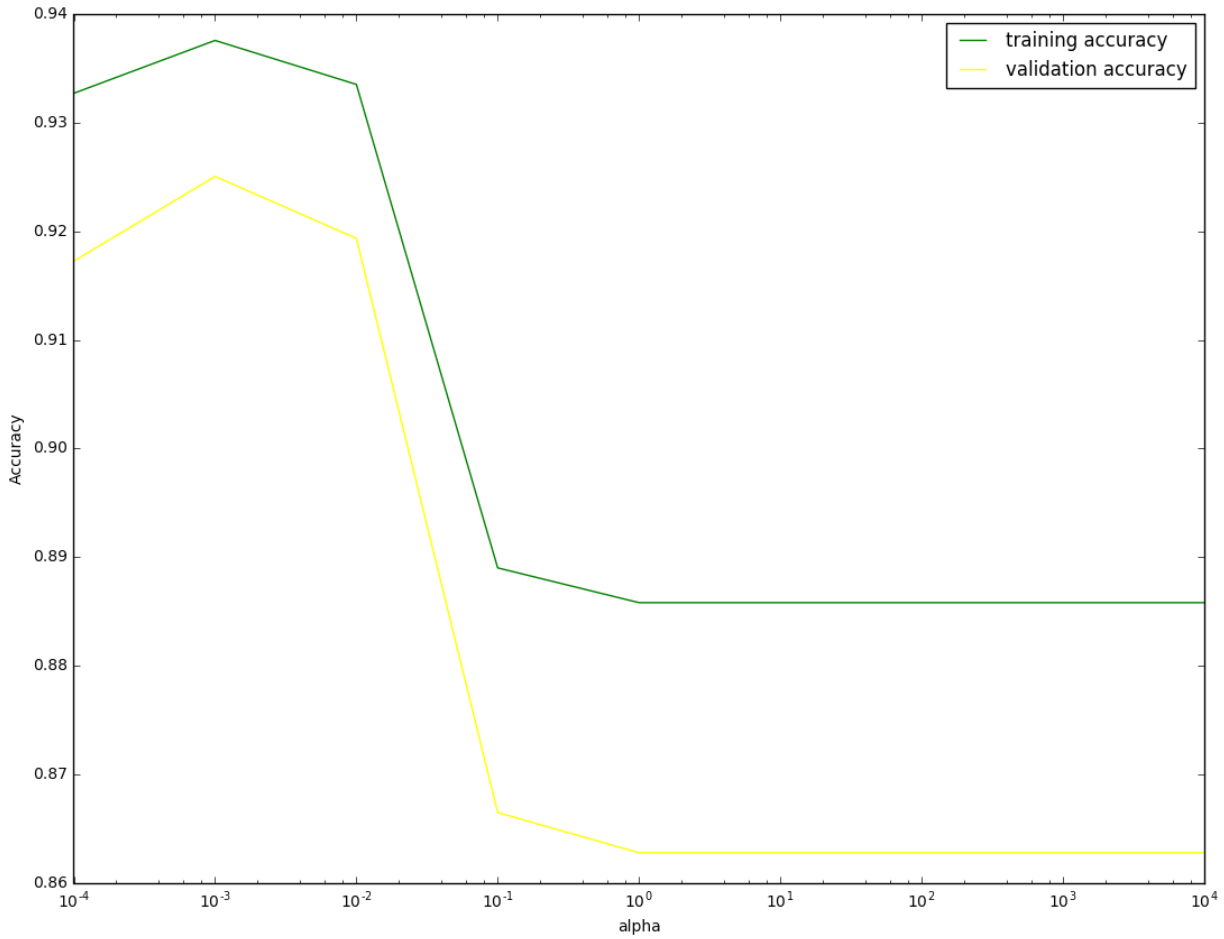
In [0]:
```
#Applying Logistic Regression with L1 regularization on BOW
from sklearn.linear_model import LogisticRegression
from tqdm import tqdm

bow_svm_train_score_list = []
bow_svm_val_score_list = []
for a_value in tqdm([0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 1000]):
    bow_clf = linear_model.SGDClassifier(loss='hinge', penalty='l2', alpha=a_valu
    bow_clf.fit(BoW_dict['X_train_vect'],Y_train)

    bow_clf_train_score = bow_clf.score(BoW_dict['X_train_vect'], Y_train)
    bow_svm_train_score_list.append(bow_clf_train_score)
    bow_clf_val_score = bow_clf.score(BoW_dict['X_val_vect'], Y_val)
    bow_svm_val_score_list.append(bow_clf_val_score)

c_all = [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
bow_train_score = dict(zip(c_all, bow_svm_train_score_list))
bow_val_score = dict(zip(c_all, bow_svm_val_score_list))
print(bow_train_score)
print(bow_val_score)
```

```
100%|████████████████████████████████████████████████████████████████████| 9/9 [00:02<0
0:00,  4.20it/s]

{0.1: 0.88901666666666668, 1: 0.8858166666666667, 100: 0.8858166666666667, 1000
0: 0.8858166666666667, 1000: 0.8858166666666667, 0.0001: 0.93269999999999997, 1
0: 0.8858166666666667, 0.01: 0.93351666666666666, 0.001: 0.93756666666666666}
{0.1: 0.86650000000000005, 1: 0.86280000000000001, 100: 0.86280000000000001, 10
000: 0.86280000000000001, 1000: 0.86280000000000001, 0.0001: 0.9172500000000000
1, 10: 0.86280000000000001, 0.01: 0.91935, 0.001: 0.92505000000000004}
```

In [0]:
```
best_a = max(bow_val_score, key=bow_val_score.get)
best_a
```

Out[200]: 0.001

In [0]:
```
import pylab
plt.figure(figsize=(13, 10))
neighbors_settings = [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
plt.plot(neighbors_settings, bow_svm_train_score_list, label="training accuracy",
plt.plot(neighbors_settings, bow_svm_val_score_list, label="validation accuracy",
# plt.plot(neighbors_settings, auc_test, label="test accuracy", color='red')
plt.xlabel('alpha')
plt.ylabel('Accuracy')
plt.legend()
plt.xscale('log')

plt.show()
```



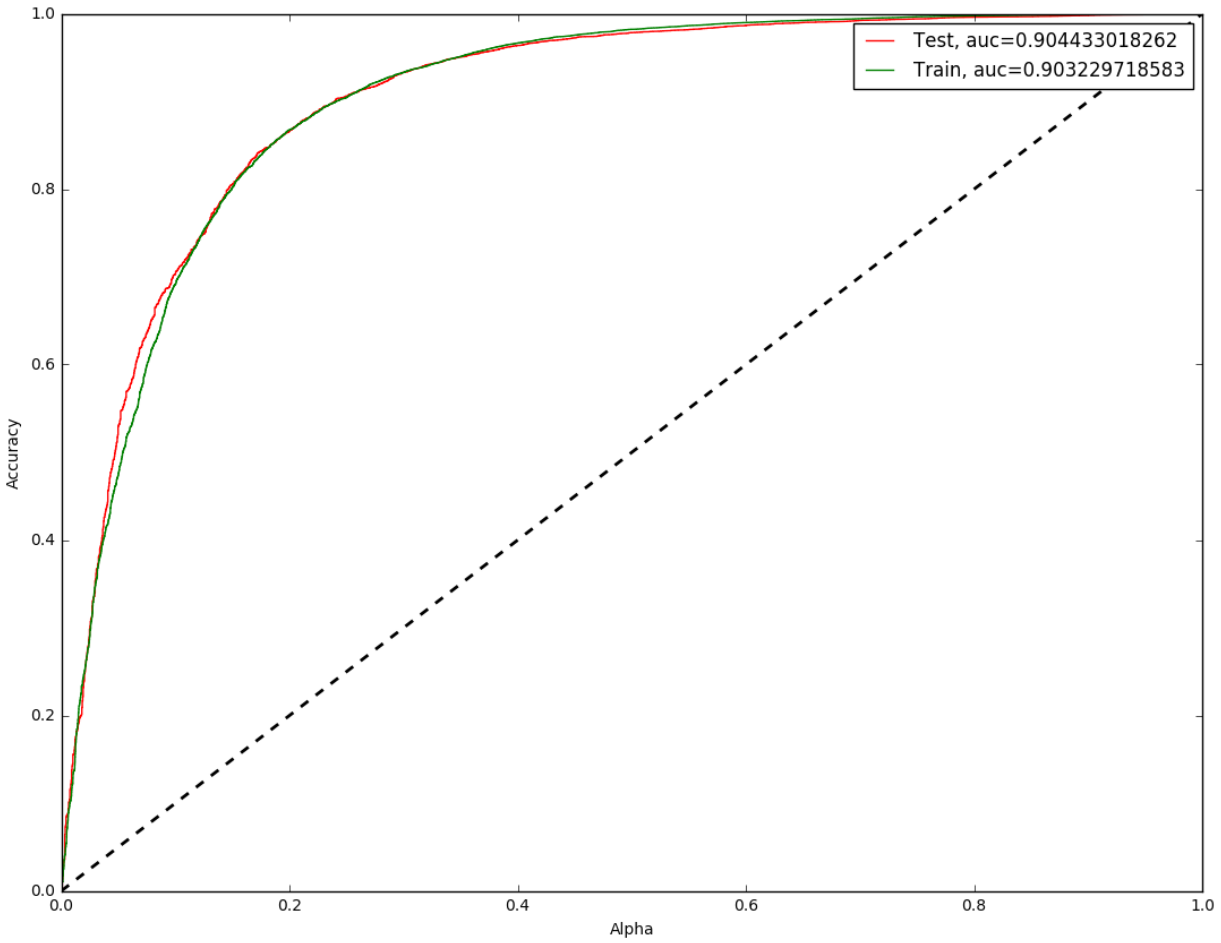
In [0]:
```
bow_svm_linear=linear_model.SGDClassifier(loss='hinge', penalty='l2', alpha=best_
bow_svm_linear.fit(BoW_dict['X_train_vect'],Y_train)
f = CalibratedClassifierCV(base_estimator=bow_svm_linear)
f.fit(BoW_dict['X_train_vect'],Y_train)
bow_linear_test_proba = f.predict_proba(BoW_dict['X_test_vect'])
bow_linear_train_proba = f.predict_proba(BoW_dict['X_train_vect'])
bow_linear_test_proba
```

Out[202]:
```
array([[ 0.03997674,  0.96002326],
       [ 0.17785007,  0.82214993],
       [ 0.00545954,  0.99454046],
       ...,
       [ 0.16841195,  0.83158805],
       [ 0.01552654,  0.98447346],
       [ 0.36460077,  0.63539923]])
```

In [0]:
```
bow_fpr_train, bow_tpr_train, _ = roc_curve(Y_train, bow_linear_train_proba[:, 1]
bow_fpr_test, bow_tpr_test, _ = roc_curve(Y_test, bow_linear_test_proba[:, 1])
bow_test_auc = auc(bow_fpr_test, bow_tpr_test)
bow_train_auc = auc(bow_fpr_train, bow_tpr_train)
print(bow_test_auc)
print(bow_train_auc)
```

```
0.904433018262
0.903229718583
```

In [0]:
```
import pylab
plt.figure(figsize=(13, 10))
plt.plot([0,1], [0,1], color='black', lw=2, linestyle='--')
plt.plot(bow_fpr_test, bow_tpr_test, label="Test, auc="+str(bow_test_auc), color =
plt.plot(bow_fpr_train, bow_tpr_train, label="Train, auc="+str(bow_train_auc), co

plt.xlabel('Alpha')
plt.ylabel('Accuracy')
plt.legend()

plt.show()
```



In [0]:
```
#https://stackoverflow.com/questions/26976362/how-to-get-most-informative-features
neg_features_labels = []
neg_features_coeff = []
neg_features_feat = []

pos_features_labels = []
pos_features_coeff = []
pos_features_feat = []
def most_informative_feature_for_binary_classification(vectorizer, classifier, n=
    class_labels = classifier.classes_
    feature_names = vectorizer.get_feature_names()
    topn_class1 = sorted(zip(classifier.coef_[0], feature_names))[:n]
    topn_class2 = sorted(zip(classifier.coef_[0], feature_names))[-n:]

    for coef, feat in topn_class1:
        neg_features_labels.append(class_labels[0])
        neg_features_coeff.append(coef)
        neg_features_feat.append(feat)

    for coef, feat in reversed(topn_class2):
        pos_features_labels.append(class_labels[1])
        pos_features_coeff.append(coef)
        pos_features_feat.append(feat)

    neg_df = pd.DataFrame({'Labels': neg_features_labels,'Coeff':neg_features_coe
    pos_df = pd.DataFrame({'Labels': pos_features_labels,'Coeff':pos_features_coe
    print("Top 10 featues for negative class \n", neg_df)
    print("Top 10 featues for positive class \n", pos_df)

f = most_informative_feature_for_binary_classification(count_vect, bow_svm_linear
```

```
Top 10 featues for negative class
       Coeff  Labels Negative features
0 -2.844990       0      disappointed
1 -2.025473       0             worst
2 -2.012147       0             money
3 -2.005485       0             awful
4 -1.968840       0          terrible
5 -1.898881       0          horrible
6 -1.625708       0             bland
7 -1.589063       0             stale
8 -1.559081       0     disappointing
9 -1.452477       0               not
Top 10 featues for positive class
       Coeff  Labels Positive features
0  3.481281       1             great
1  3.251417       1              best
2  3.201446       1         delicious
3  2.648439       1         excellent
4  2.232018       1         wonderful
5  2.188710       1           perfect
6  2.072112       1             loves
7  1.948851       1              nice
8  1.898881       1          favorite
9  1.878893       1             yummy
```

In [0]:
```
bow_test_conf = bow_svm_linear.predict(BoW_dict['X_test_vect'])
```

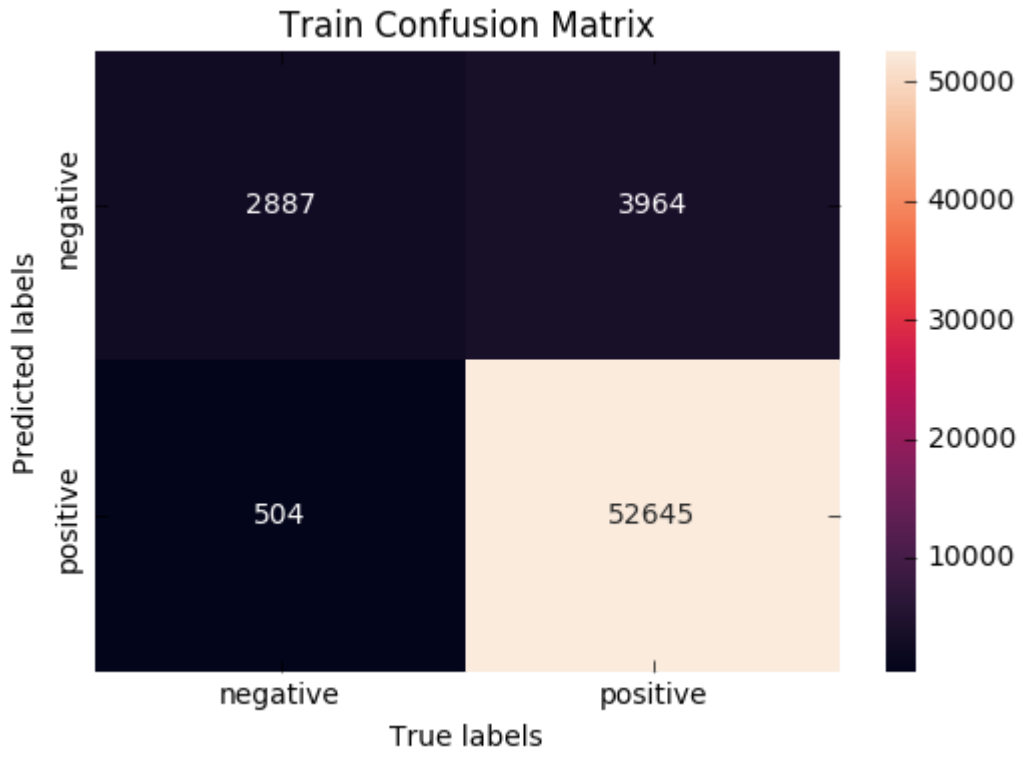
In [0]:
```
bow_train_conf = bow_svm_linear.predict(BoW_dict['X_train_vect'])
```

In [0]:
```
from sklearn.metrics import classification_report, confusion_matrix
bow_train_conf_matrix = confusion_matrix(Y_train, bow_train_conf)
bow_test_conf_matrix = confusion_matrix(Y_test, bow_test_conf)
class_report = classification_report(Y_test, bow_test_conf)
print(bow_test_conf_matrix)
print(class_report)
```

```
[[ 1177  1499]
 [  257 17067]]
             precision    recall  f1-score   support

          0       0.82      0.44      0.57      2676
          1       0.92      0.99      0.95     17324

avg / total       0.91      0.91      0.90     20000
```

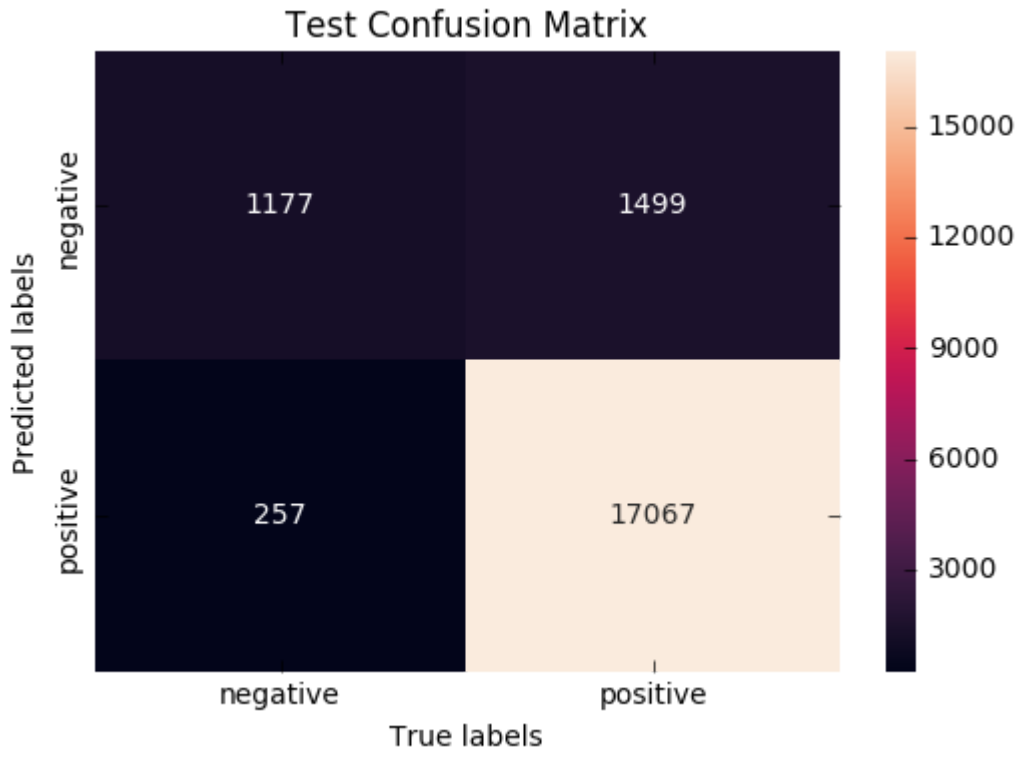
In [0]:
```
ax= plt.subplot()
sns.heatmap(bow_train_conf_matrix, annot=True, ax = ax, fmt='g')

ax.set_ylabel('Predicted labels')
ax.set_xlabel('True labels')
ax.set_title('Train Confusion Matrix')
ax.xaxis.set_ticklabels(['negative', 'positive'])
ax.yaxis.set_ticklabels(['negative', 'positive'])
```

Out[209]: [<matplotlib.text.Text at 0x636d26a0>, <matplotlib.text.Text at 0x58fbacf8>]



In [0]:
```
ax= plt.subplot()
sns.heatmap(bow_test_conf_matrix, annot=True, ax = ax, fmt='g')

ax.set_ylabel('Predicted labels')
ax.set_xlabel('True labels')
ax.set_title('Test Confusion Matrix')
ax.xaxis.set_ticklabels(['negative', 'positive'])
ax.yaxis.set_ticklabels(['negative', 'positive'])
```

Out[210]:
```
[<matplotlib.text.Text at 0x22283128>, <matplotlib.text.Text at 0x78b15da0>]
```



SVM on TF-IDF (Linear)

In [0]:
```
import pickle
with open(r"tf_idf.pkl", "rb") as input_file:
    tfidf_dict = pickle.load(input_file)
```

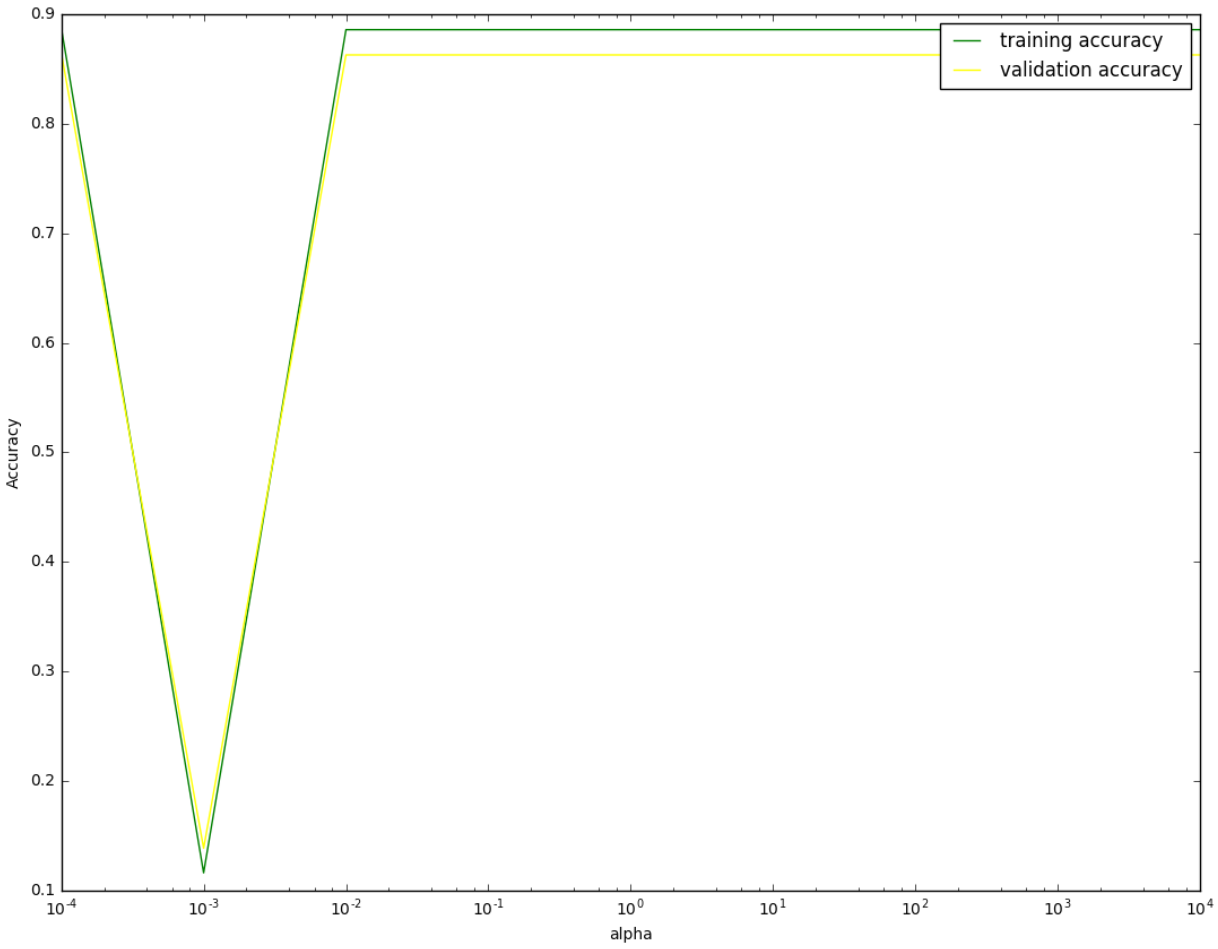
In [0]:
```
tfidf_svm_train_score_list = []
tfidf_svm_val_score_list = []
for all_a in tqdm([0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 1000]):
    tfidfclf = linear_model.SGDClassifier(loss='hinge', penalty='l2', alpha=all_a
    tfidfclf.fit(tfidf_dict['train_tf_idf'],Y_train)

    tfidf_svm_train_score = tfidfclf.score(tfidf_dict['train_tf_idf'], Y_train)
    tfidf_svm_train_score_list.append(tfidf_svm_train_score)
    tfidf_svm_val_score = tfidfclf.score(tfidf_dict['cv_tf_idf'], Y_val)
    tfidf_svm_val_score_list.append(tfidf_svm_val_score)

c_all = [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
tfidf_train_score = dict(zip(c_all, tfidf_svm_train_score_list))
tfidf_val_scores = dict(zip(c_all, tfidf_svm_val_score_list))
print(tfidf_train_score)
print(tfidf_val_scores)
```

```
100%|████████████████████████████████████████████████████████████| 9/9 [00:02<0
0:00,  3.77it/s]

{0.1: 0.8858166666666667, 1: 0.8858166666666667, 100: 0.8858166666666667, 1000
0: 0.8858166666666667, 1000: 0.8858166666666667, 0.0001: 0.88754999999999995, 1
0: 0.8858166666666667, 0.01: 0.8858166666666667, 0.001: 0.11625000000000001}
{0.1: 0.86280000000000001, 1: 0.86280000000000001, 100: 0.86280000000000001, 10
000: 0.86280000000000001, 1000: 0.86280000000000001, 0.0001: 0.8647500000000000
2, 10: 0.86280000000000001, 0.01: 0.86280000000000001, 0.001: 0.13865}
```

In [0]:
```
tfidf_best_a = max(tfidf_val_scores, key=tfidf_val_scores.get)
tfidf_best_a
```

Out[364]:
```
0.0001
```

In [0]:
```
import pylab
plt.figure(figsize=(13, 10))
neighbors_settings = [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
plt.plot(neighbors_settings, tfidf_svm_train_score_list, label="training accuracy
plt.plot(neighbors_settings, tfidf_svm_val_score_list, label="validation accuracy
# plt.plot(neighbors_settings, auc_test, label="test accuracy", color='red')
plt.xlabel('alpha')
plt.ylabel('Accuracy')
plt.legend()
plt.xscale('log')

plt.show()
```



In [0]:
```
tfidf_svm_linear=linear_model.SGDClassifier(loss='hinge', penalty='l2', alpha=bes
tfidf_svm_linear.fit(tfidf_dict['train_tf_idf'], Y_train)
f = CalibratedClassifierCV(base_estimator=bow_svm_linear)
f.fit(tfidf_dict['train_tf_idf'], Y_train)
tfidf_linear_test_proba = f.predict_proba(tfidf_dict['test_tf_idf'])
tfidf_linear_train_proba = f.predict_proba(tfidf_dict['train_tf_idf'])
tfidf_linear_test_proba
```

Out[366]:
```
array([[ 0.11354938,  0.88645062],
       [ 0.11459146,  0.88540854],
       [ 0.11413437,  0.88586563],
       ...,
       [ 0.11368474,  0.88631526],
       [ 0.11330243,  0.88669757],
       [ 0.11423827,  0.88576173]])
```

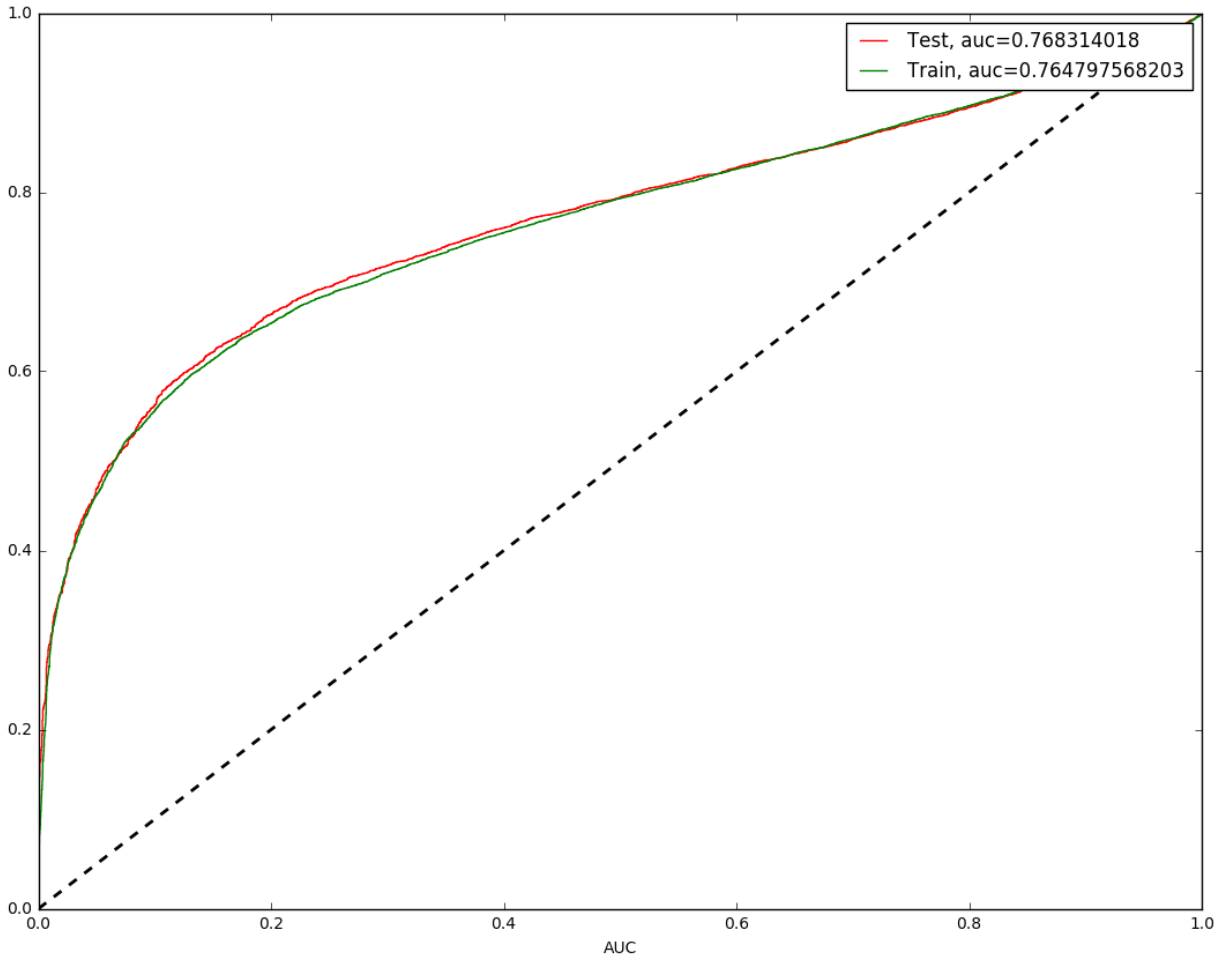
In [0]:
```
#https://stackoverflow.com/questions/26976362/how-to-get-most-informative-features
neg_features_labels = []
neg_features_coeff = []
neg_features_feat = []

pos_features_labels = []
pos_features_coeff = []
pos_features_feat = []
def most_informative_feature_for_binary_classification(vectorizer, classifier, n=
    class_labels = classifier.classes_
    feature_names = vectorizer.get_feature_names()
    topn_class1 = sorted(zip(classifier.coef_[0], feature_names))[:n]
    topn_class2 = sorted(zip(classifier.coef_[0], feature_names))[-n:]

    for coef, feat in topn_class1:
        neg_features_labels.append(class_labels[0])
        neg_features_coeff.append(coef)
        neg_features_feat.append(feat)

    for coef, feat in reversed(topn_class2):
        pos_features_labels.append(class_labels[1])
        pos_features_coeff.append(coef)
        pos_features_feat.append(feat)

    neg_df = pd.DataFrame({'Labels': neg_features_labels,'Coeff':neg_features_coe
    pos_df = pd.DataFrame({'Labels': pos_features_labels,'Coeff':pos_features_coe
    print("Top 10 featues for negative class \n", neg_df)
    print("Top 10 featues for positive class \n", pos_df)

f = most_informative_feature_for_binary_classification(tf_idf_vect, tfidf_svm_lin
```

```
Top 10 featues for negative class
       Coeff  Labels Negative features
0 -2.707195       0              not
1 -0.901843       0              bad
2 -0.887087       0     disappointed
3 -0.830637       0            would
4 -0.750159       0            money
5 -0.684442       0          not buy
6 -0.650887       0            awful
7 -0.632034       0        would not
8 -0.629365       0         terrible
9 -0.616957       0         not good
Top 10 featues for positive class
       Coeff  Labels Positive features
0  2.165727       1            great
1  1.433100       1             best
2  1.146839       1             love
3  1.036500       1             good
4  1.017636       1        delicious
5  1.008281       1              tea
6  0.792217       1        excellent
7  0.682033       1        wonderful
8  0.673267       1         favorite
9  0.634391       1          perfect
```

In [0]:
```
tfidf_fpr_train, tfidf_tpr_train, _ = roc_curve(Y_train, tfidf_linear_train_proba
tfidf_fpr_test, tfidf_tpr_test, _ = roc_curve(Y_test, tfidf_linear_test_proba[:,
tfidf_test_auc = auc(tfidf_fpr_test, tfidf_tpr_test)
tfidf_train_auc = auc(tfidf_fpr_train, tfidf_tpr_train)
print(tfidf_test_auc)
print(tfidf_train_auc)
```

```
0.768314018
0.764797568203
```

In [0]:
```
import pylab
plt.figure(figsize=(13, 10))
plt.plot([0,1], [0,1], color='black', lw=2, linestyle='--')
plt.plot(tfidf_fpr_test, tfidf_tpr_test, label="Test, auc="+str(tfidf_test_auc),
plt.plot(tfidf_fpr_train, tfidf_tpr_train, label="Train, auc="+str(tfidf_train_au

plt.xlabel('AUC')
plt.legend()

plt.show()
```



In [0]:
```
tfidf_test_conf = tfidf_svm_linear.predict(tfidf_dict['test_tf_idf'])
```

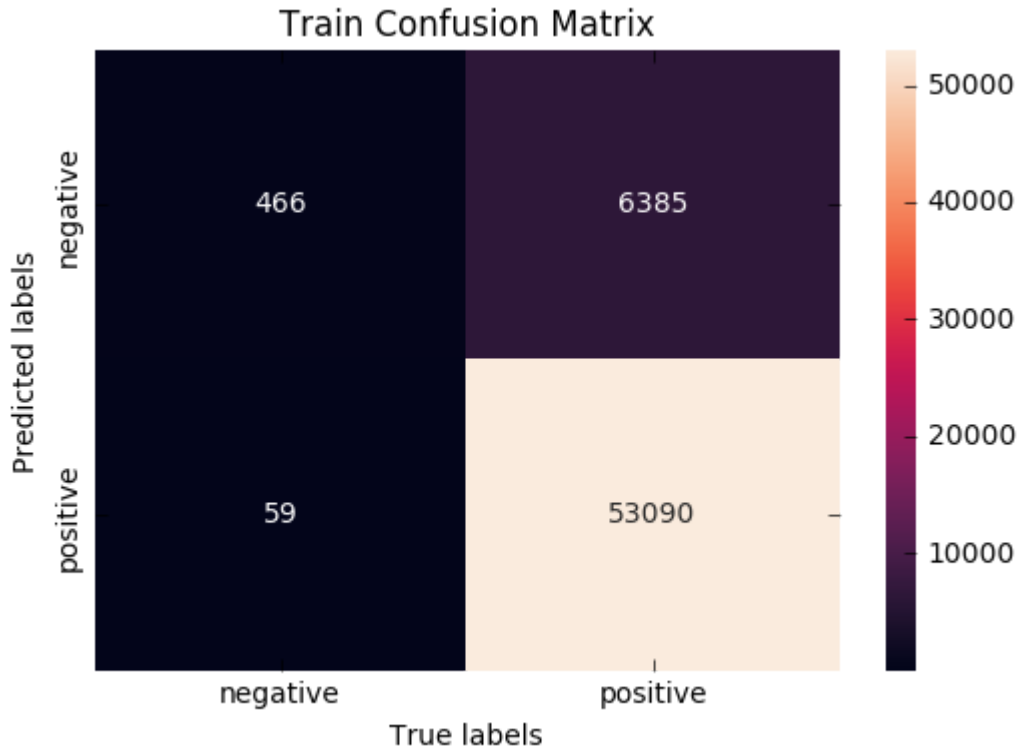
In [0]:
```
tfidf_train_conf = tfidf_svm_linear.predict(tfidf_dict['train_tf_idf'])
```

In [0]:
```
from sklearn.metrics import classification_report, confusion_matrix
tfidf_test_conf_matrix = confusion_matrix(Y_test, tfidf_test_conf)
tfidf_train_conf_matrix = confusion_matrix(Y_train, tfidf_train_conf)
class_report = classification_report(Y_test, tfidf_test_conf)
print(tfidf_test_conf_matrix)
print(class_report)
```

```
[[  191  2485]
 [   26 17298]]
             precision    recall  f1-score   support

          0       0.88      0.07      0.13      2676
          1       0.87      1.00      0.93     17324

avg / total       0.88      0.87      0.83     20000
```

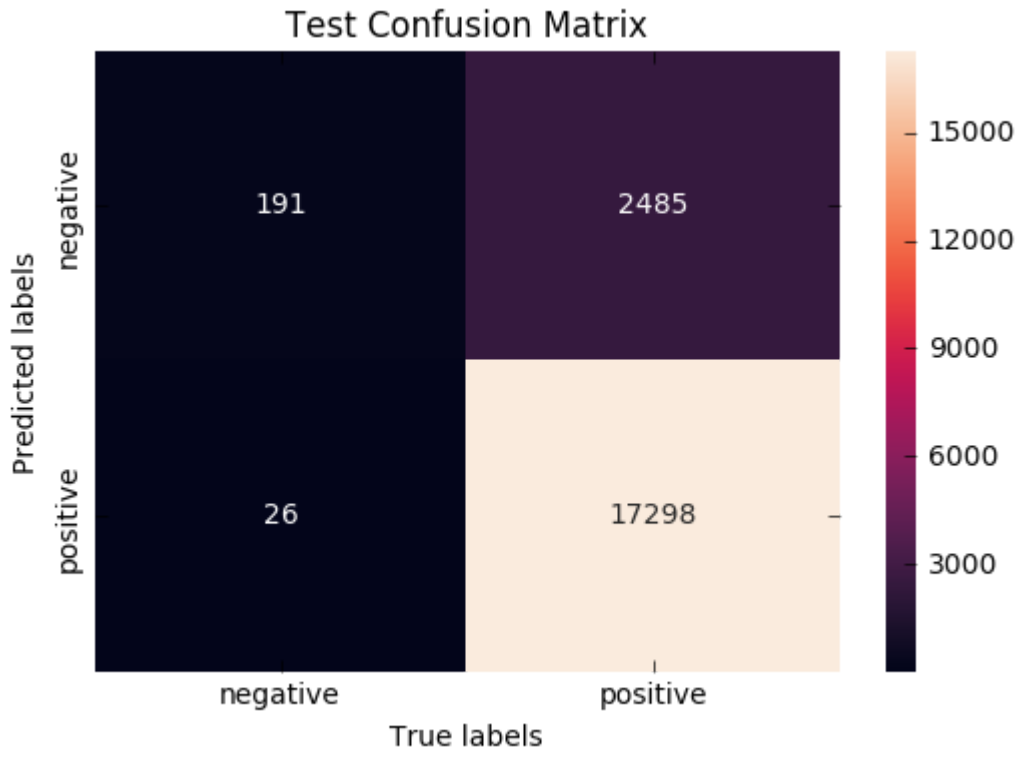
In [0]:
```
ax= plt.subplot()
sns.heatmap(tfidf_train_conf_matrix, annot=True, ax = ax, fmt='g')

ax.set_ylabel('Predicted labels')
ax.set_xlabel('True labels')
ax.set_title('Train Confusion Matrix')
ax.xaxis.set_ticklabels(['negative', 'positive'])
ax.yaxis.set_ticklabels(['negative', 'positive'])
```

Out[373]: [<matplotlib.text.Text at 0x34406f60>, <matplotlib.text.Text at 0x694dd0b8>]



In [0]:
```
ax= plt.subplot()
sns.heatmap(tfidf_test_conf_matrix, annot=True, ax = ax, fmt='g')

ax.set_ylabel('Predicted labels')
ax.set_xlabel('True labels')
ax.set_title('Test Confusion Matrix')
ax.xaxis.set_ticklabels(['negative', 'positive'])
ax.yaxis.set_ticklabels(['negative', 'positive'])
```

Out[374]: [<matplotlib.text.Text at 0x36d304a8>, <matplotlib.text.Text at 0x32146668>]



SVM on Avg-W2V

In [0]:
```
import pickle
with open(r"avg_w2v.pkl", "rb") as input_file:
    avg_tfidf_dict = pickle.load(input_file)
```

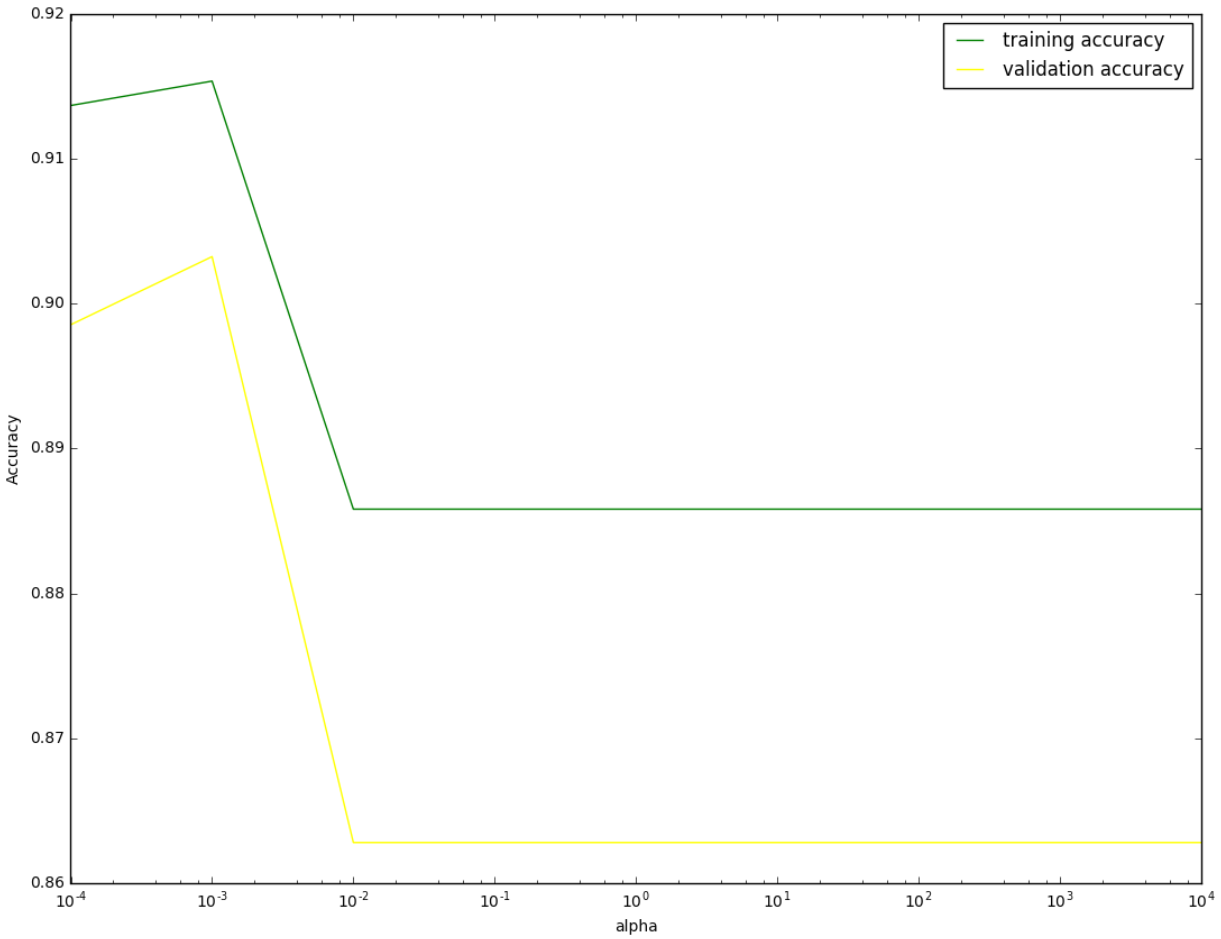
In [0]:
```
avg_lgr_train_score_list = []
avg_lgr_val_score_list = []
for a_value in tqdm([0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]):
    avg_lgr=linear_model.SGDClassifier(loss='hinge', penalty='l1', alpha=a_value)
    avg_lgr.fit(avg_tfidf_dict['X_train_avgw2v'],Y_train)

    avg_lgr_train_score = avg_lgr.score(avg_tfidf_dict['X_train_avgw2v'], Y_train
    avg_lgr_train_score_list.append(avg_lgr_train_score)
    avg_lgr_val_score = avg_lgr.score(avg_tfidf_dict['X_val_avgw2v'], Y_val)
    avg_lgr_val_score_list.append(avg_lgr_val_score)

c_all = [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
avg_train_score = dict(zip(c_all, avg_lgr_train_score_list))
avg_val_score = dict(zip(c_all, avg_lgr_val_score_list))
print(avg_train_score)
print(avg_val_score)
```

```
100%|██████████████████████████████████████████████████████████████████████| 9/9 [00:02<0
0:00,  4.35it/s]

{0.1: 0.8858166666666667, 1: 0.8858166666666667, 100: 0.8858166666666667, 1000
0: 0.8858166666666667, 1000: 0.8858166666666667, 0.0001: 0.91368333333333329, 1
0: 0.8858166666666667, 0.01: 0.8858166666666667, 0.001: 0.91536666666666666}
{0.1: 0.86280000000000001, 1: 0.86280000000000001, 100: 0.86280000000000001, 10
000: 0.86280000000000001, 1000: 0.86280000000000001, 0.0001: 0.8985499999999999
6, 10: 0.86280000000000001, 0.01: 0.86280000000000001, 0.001: 0.90325}
```

In [0]:
```
best_a = max(avg_val_score, key=avg_val_score.get)
best_a
```

Out[248]: 0.001

In [0]:
```
import pylab
plt.figure(figsize=(13, 10))
neighbors_settings = [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
plt.plot(neighbors_settings, avg_lgr_train_score_list, label="training accuracy",
plt.plot(neighbors_settings, avg_lgr_val_score_list, label="validation accuracy",
# plt.plot(neighbors_settings, auc_test, label="test accuracy", color='red')
plt.xlabel('alpha')
plt.ylabel('Accuracy')
plt.legend()
plt.xscale('log')

plt.show()
```



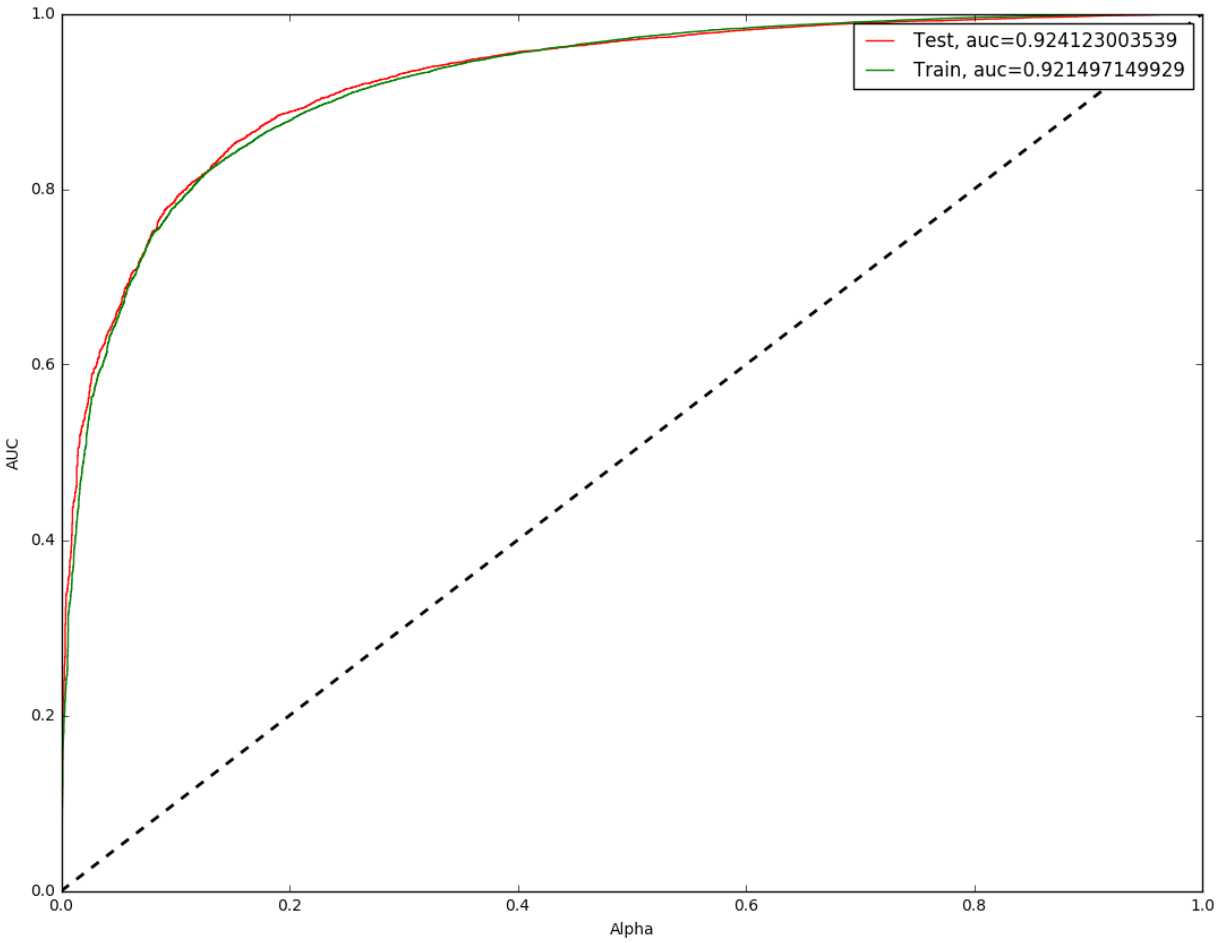
In [0]:
```
avg_svm_linear=linear_model.SGDClassifier(loss='hinge', penalty='l2', alpha=best_
avg_svm_linear.fit(avg_tfidf_dict['X_train_avgw2v'], Y_train)
f = CalibratedClassifierCV(base_estimator=bow_svm_linear)
f.fit(avg_tfidf_dict['X_train_avgw2v'], Y_train)
avg_linear_test_proba = f.predict_proba(avg_tfidf_dict['X_test_avgw2v'])
avg_linear_train_proba = f.predict_proba(avg_tfidf_dict['X_train_avgw2v'])
avg_linear_test_proba
```

Out[250]:
```
array([[  1.93320313e-03,   9.98066797e-01],
       [  8.58651105e-01,   1.41348895e-01],
       [  2.10185104e-02,   9.78981490e-01],
       ...,
       [  1.21741529e-01,   8.78258471e-01],
       [  8.67555402e-06,   9.99991324e-01],
       [  1.91983420e-01,   8.08016580e-01]])
```

In [0]:
```
avg_fpr_train, avg_tpr_train, _ = roc_curve(Y_train, avg_linear_train_proba[:, 1]
avg_fpr_test, avg_tpr_test, _ = roc_curve(Y_test, avg_linear_test_proba[:, 1])
avg_test_auc = auc(avg_fpr_test, avg_tpr_test)
avg_train_auc = auc(avg_fpr_train, avg_tpr_train)
print(avg_test_auc)
print(avg_train_auc)
```

```
0.924123003539
0.921497149929
```

In [0]:
```
import pylab
plt.figure(figsize=(13, 10))
plt.plot([0,1], [0,1], color='black', lw=2, linestyle='--')
plt.plot(avg_fpr_test, avg_tpr_test, label="Test, auc="+str(avg_test_auc), color
plt.plot(avg_fpr_train, avg_tpr_train, label="Train, auc="+str(avg_train_auc), co

plt.xlabel('Alpha')
plt.ylabel('AUC')
plt.legend()

plt.show()
```



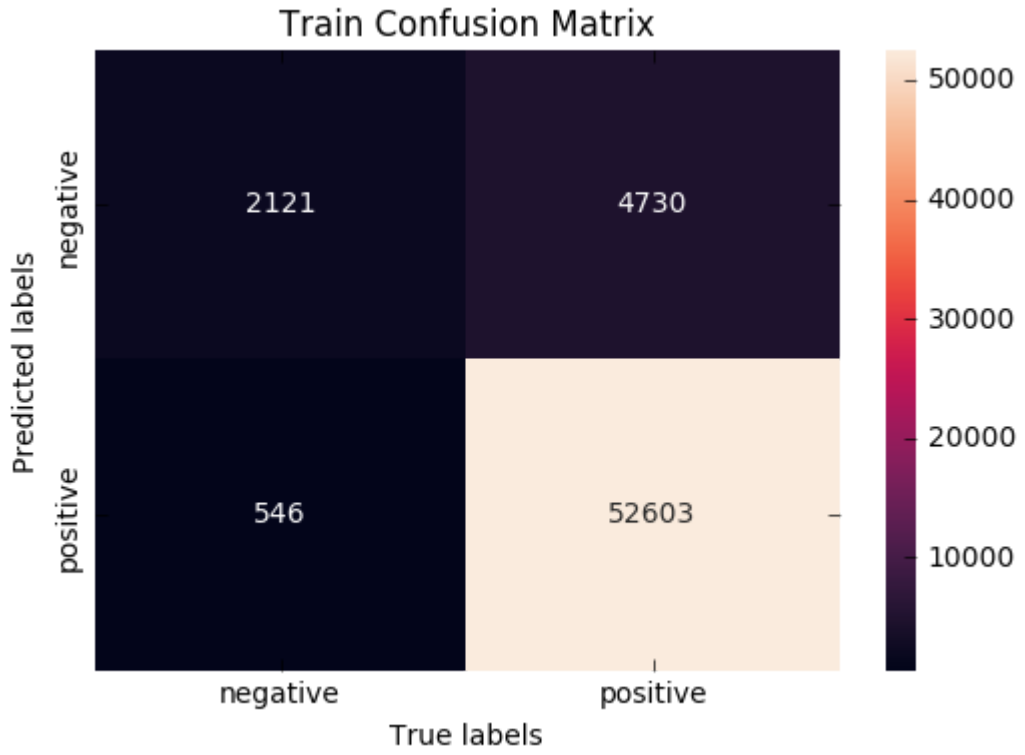
In [0]:
```
avg_test_conf = avg_svm_linear.predict(avg_tfidf_dict['X_test_avgw2v'])
avg_train_conf = avg_svm_linear.predict(avg_tfidf_dict['X_train_avgw2v'])
```

In [0]:
```
from sklearn.metrics import classification_report, confusion_matrix
avg_test_conf_matrix = confusion_matrix(Y_test, avg_test_conf)
avg_train_conf_matrix = confusion_matrix(Y_train, avg_train_conf)
class_report = classification_report(Y_test, avg_test_conf)
print(avg_test_conf_matrix)
print(class_report)
```

```
[[  807  1869]
 [  205 17119]]
             precision    recall  f1-score   support

          0       0.80      0.30      0.44      2676
          1       0.90      0.99      0.94     17324

avg / total       0.89      0.90      0.88     20000
```

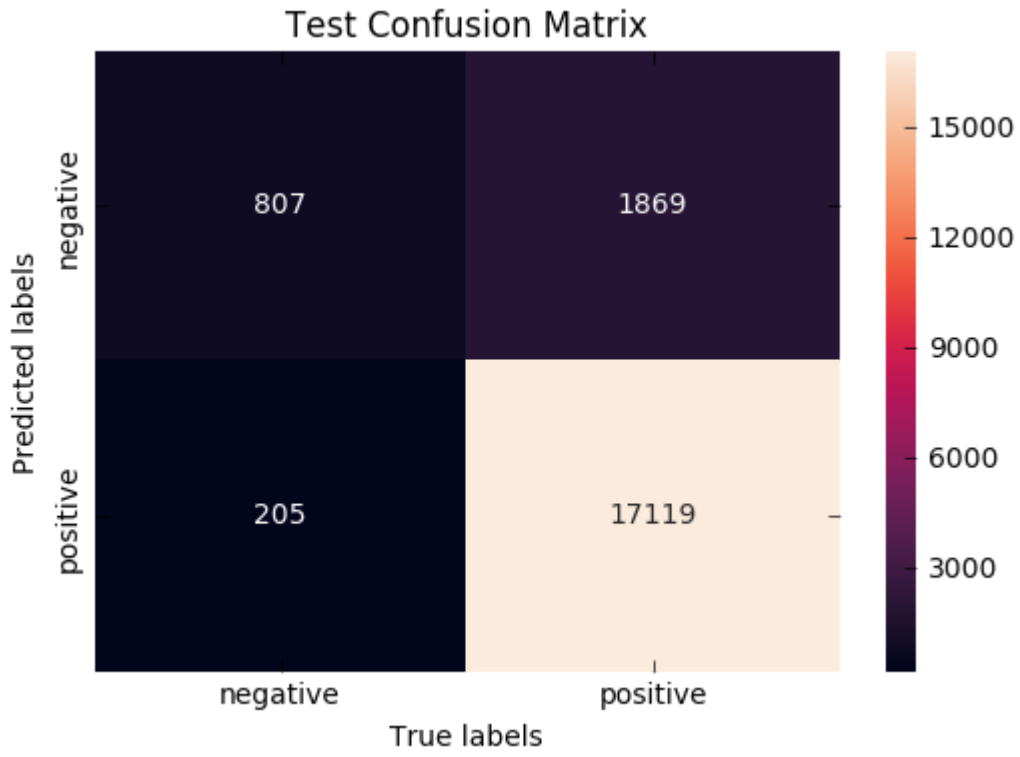
In [0]:
```
ax= plt.subplot()
sns.heatmap(avg_train_conf_matrix, annot=True, ax = ax, fmt='g')

ax.set_ylabel('Predicted labels')
ax.set_xlabel('True labels')
ax.set_title('Train Confusion Matrix')
ax.xaxis.set_ticklabels(['negative', 'positive'])
ax.yaxis.set_ticklabels(['negative', 'positive'])
```

Out[255]: [<matplotlib.text.Text at 0x3a8491d0>, <matplotlib.text.Text at 0x42418630>]



In [0]:
```
ax= plt.subplot()
sns.heatmap(avg_test_conf_matrix, annot=True, ax = ax, fmt='g')

ax.set_ylabel('Predicted labels')
ax.set_xlabel('True labels')
ax.set_title('Test Confusion Matrix')
ax.xaxis.set_ticklabels(['negative', 'positive'])
ax.yaxis.set_ticklabels(['negative', 'positive'])
```

Out[256]:
```
[<matplotlib.text.Text at 0x2a4c0da0>, <matplotlib.text.Text at 0x71a02ba8>]
```



SVM on tfidf_w2v

In [0]:
```
import pickle
with open(r"tfidf_w2v.pkl", "rb") as input_file:
    tfidfw2v_dict = pickle.load(input_file)
```

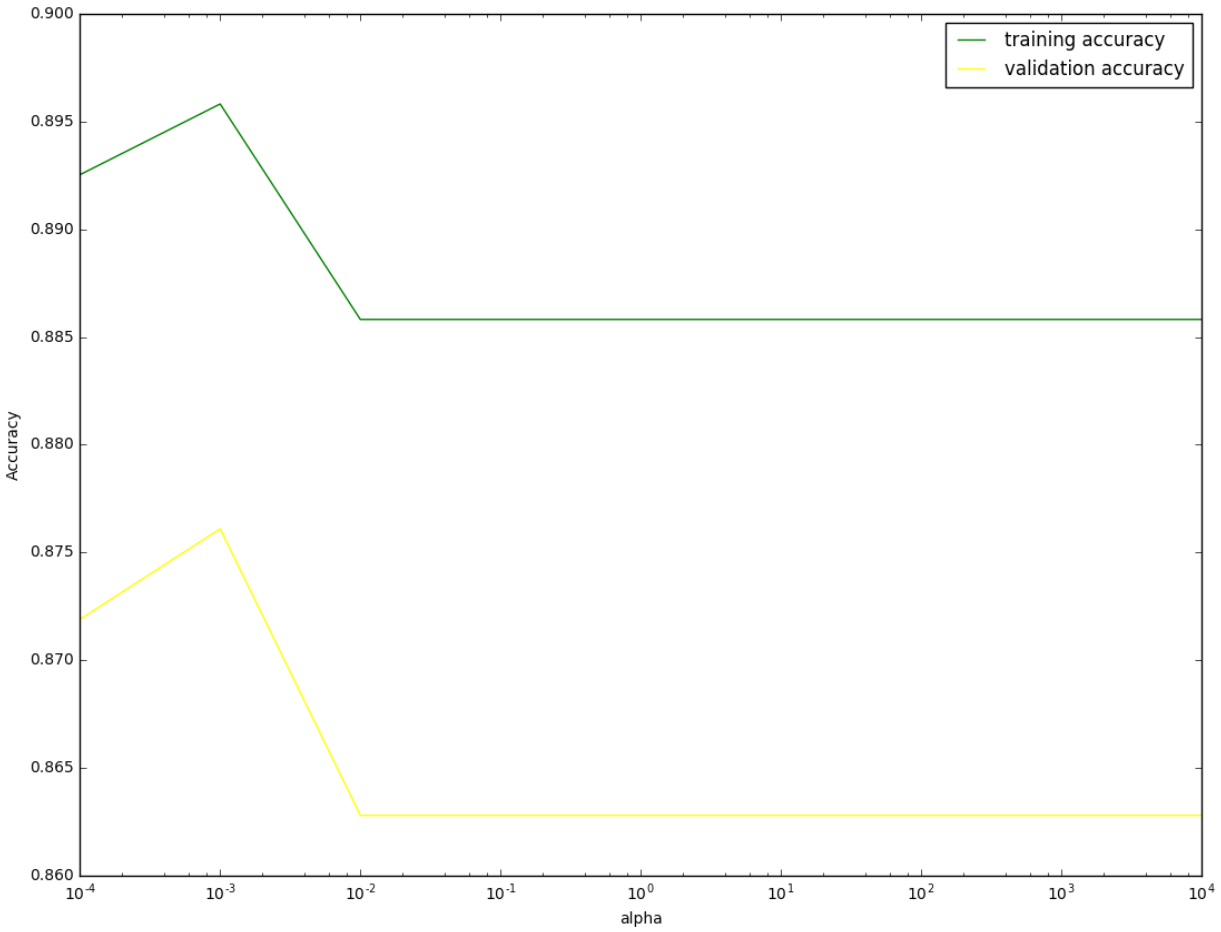
In [0]:
```
from sklearn.linear_model import LogisticRegression
from tqdm import tqdm

tfidfw2v_lgr_train_score_list = []
tfidfw2v_lgr_val_score_list = []
for a_value in tqdm([0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]):
    tfidfw2v_lgr=linear_model.SGDClassifier(loss='hinge', penalty='l1', alpha=a_v
    tfidfw2v_lgr.fit(tfidfw2v_dict['X_train_tfidfw2v'],Y_train)

    tfidfw2v_lgr_train_score = tfidfw2v_lgr.score(tfidfw2v_dict['X_train_tfidfw2v
    tfidfw2v_lgr_train_score_list.append(tfidfw2v_lgr_train_score)
    tfidfw2v_lgr_val_score = tfidfw2v_lgr.score(tfidfw2v_dict['X_val_tfidfw2v'], 
    tfidfw2v_lgr_val_score_list.append(tfidfw2v_lgr_val_score)

c_all = [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
tfidfw2v_train_score = dict(zip(c_all, tfidfw2v_lgr_train_score_list))
tfidfw2v_val_score = dict(zip(c_all, tfidfw2v_lgr_val_score_list))
print(tfidfw2v_train_score)
print(tfidfw2v_val_score)
```

```
100%|████████████████████████████████████████████████████████████| 9/9 [00:02<0
0:00,  4.19it/s]

{0.1: 0.8858166666666667, 1: 0.8858166666666667, 100: 0.8858166666666667, 1000
0: 0.8858166666666667, 1000: 0.8858166666666667, 0.0001: 0.89253333333333329, 1
0: 0.8858166666666667, 0.01: 0.8858166666666667, 0.001: 0.89581666666666671}
{0.1: 0.86280000000000001, 1: 0.86280000000000001, 100: 0.86280000000000001, 10
000: 0.86280000000000001, 1000: 0.86280000000000001, 0.0001: 0.8719000000000000
1, 10: 0.86280000000000001, 0.01: 0.86280000000000001, 0.001: 0.876099999999999
99}
```

In [0]:
```
best_a = max(tfidfw2v_val_score, key=tfidfw2v_val_score.get)
best_a
```

Out[378]: 0.001

In [0]:
```
import pylab
plt.figure(figsize=(13, 10))
neighbors_settings = [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
plt.plot(neighbors_settings, tfidfw2v_lgr_train_score_list, label="training accur
plt.plot(neighbors_settings, tfidfw2v_lgr_val_score_list, label="validation accur
# plt.plot(neighbors_settings, auc_test, label="test accuracy", color='red')
plt.xlabel('alpha')
plt.ylabel('Accuracy')
plt.legend()
plt.xscale('log')

plt.show()
```



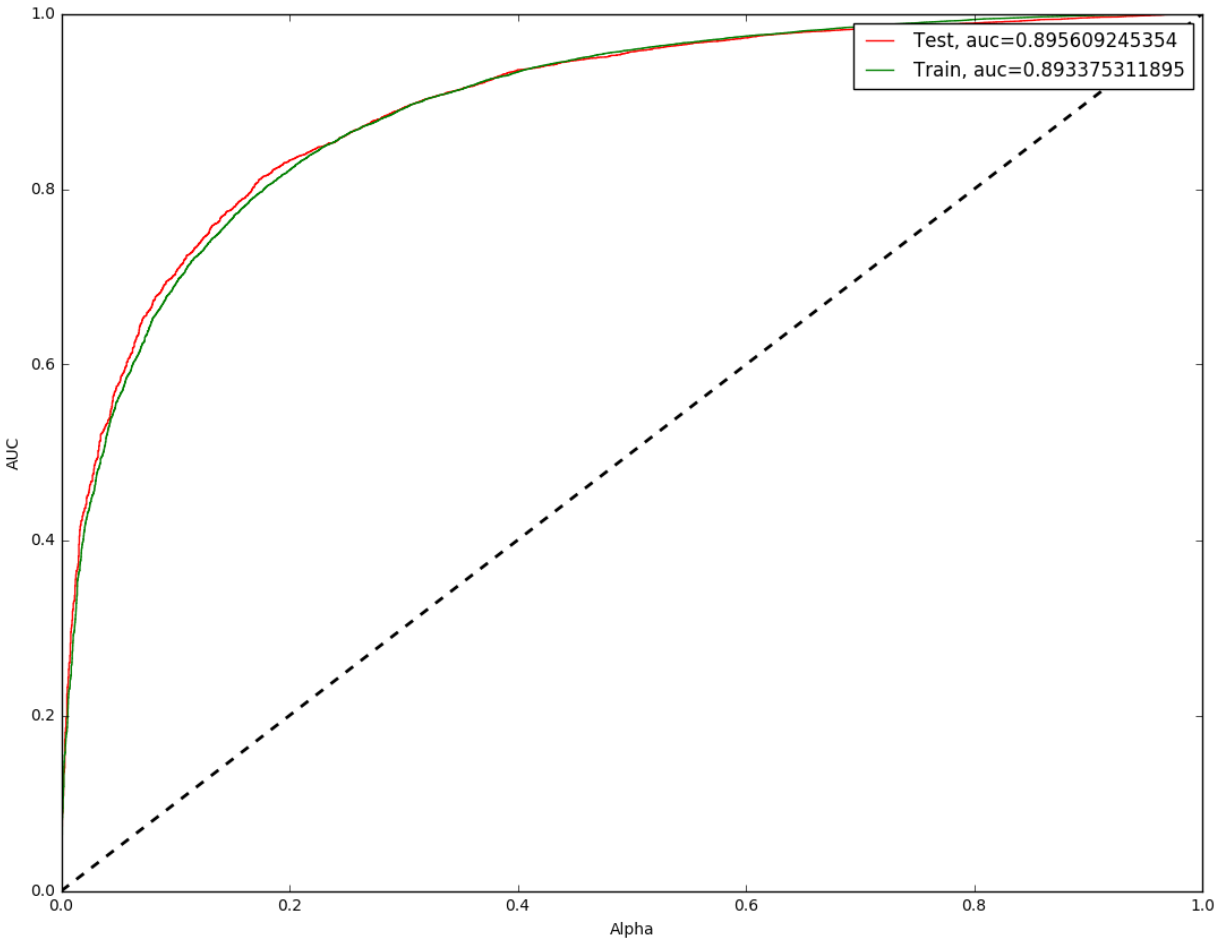
In [0]:
```
tfidfw2v_svm_linear=linear_model.SGDClassifier(loss='hinge', penalty='l2', alpha=
tfidfw2v_svm_linear.fit(tfidfw2v_dict['X_train_tfidfw2v'], Y_train)
f = CalibratedClassifierCV(base_estimator=bow_svm_linear)
f.fit(tfidfw2v_dict['X_train_tfidfw2v'], Y_train)
tfidfw2v_test_proba = f.predict_proba(tfidfw2v_dict['X_test_tfidfw2v'])
tfidfw2v_train_proba = f.predict_proba(tfidfw2v_dict['X_train_tfidfw2v'])
tfidfw2v_test_proba
```

Out[384]:
```
array([[  5.67270863e-02,   9.43272914e-01],
       [  6.19355514e-01,   3.80644486e-01],
       [  1.62112882e-02,   9.83788712e-01],
       ...,
       [  1.35165571e-01,   8.64834429e-01],
       [  5.30136402e-04,   9.99469864e-01],
       [  2.91473317e-01,   7.08526683e-01]])
```

In [0]:
```
tfidfw2v_fpr_train, tfidfw2v_tpr_train, _ = roc_curve(Y_train, tfidfw2v_train_pro
tfidfw2v_fpr_test, tfidfw2v_tpr_test, _ = roc_curve(Y_test, tfidfw2v_test_proba[:
tfidfw2v_test_auc = auc(tfidfw2v_fpr_test, tfidfw2v_tpr_test)
tfidfw2v_train_auc = auc(tfidfw2v_fpr_train, tfidfw2v_tpr_train)
print(tfidfw2v_test_auc)
print(tfidfw2v_train_auc)
```

```
0.895609245354
0.893375311895
```

In [0]:
```
import pylab
plt.figure(figsize=(13, 10))
plt.plot([0,1], [0,1], color='black', lw=2, linestyle='--')
plt.plot(tfidfw2v_fpr_test, tfidfw2v_tpr_test, label="Test, auc="+str(tfidfw2v_te
plt.plot(tfidfw2v_fpr_train, tfidfw2v_tpr_train, label="Train, auc="+str(tfidfw2v_

plt.xlabel('Alpha')
plt.ylabel('AUC')
plt.legend()

plt.show()
```



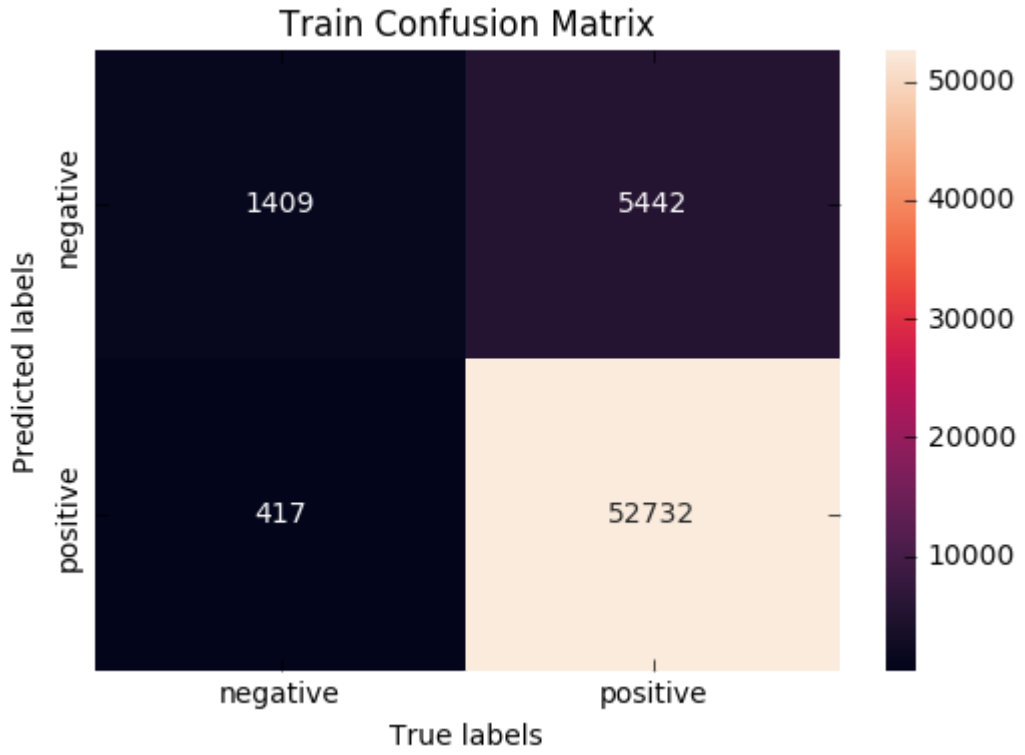
In [0]:
```
tfidfw2v_test_conf = tfidfw2v_svm_linear.predict(tfidfw2v_dict['X_test_tfidfw2v']
tfidfw2v_train_conf = tfidfw2v_svm_linear.predict(tfidfw2v_dict['X_train_tfidfw2v
```

In [0]:
```
from sklearn.metrics import classification_report, confusion_matrix
tfidfw2v_test_conf_matrix = confusion_matrix(Y_test, tfidfw2v_test_conf)
tfidfw2v_train_conf_matrix = confusion_matrix(Y_train, tfidfw2v_train_conf)
class_report = classification_report(Y_test, tfidfw2v_test_conf)
print(tfidfw2v_train_conf_matrix)
print(class_report)
```

```
[[ 1409  5442]
 [  417 52732]]
             precision    recall  f1-score   support

          0       0.73      0.19      0.30      2676
          1       0.89      0.99      0.94     17324

avg / total       0.87      0.88      0.85     20000
```

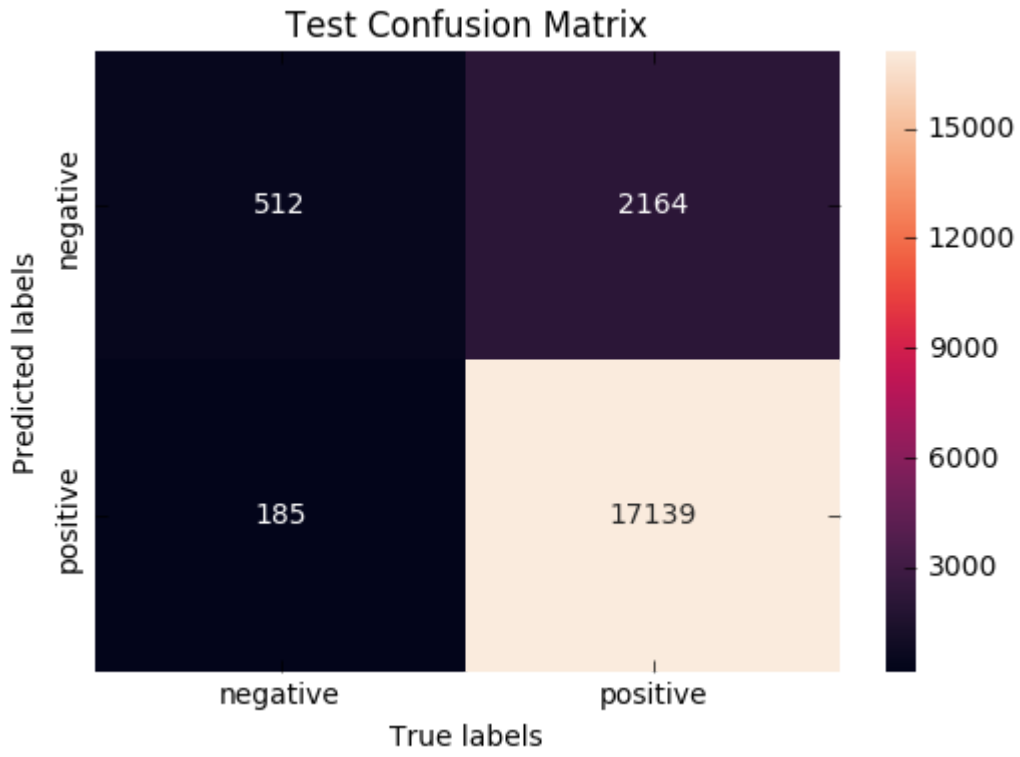
In [0]:
```
ax= plt.subplot()
sns.heatmap(tfidfw2v_train_conf_matrix, annot=True, ax = ax, fmt='g')

ax.set_ylabel('Predicted labels')
ax.set_xlabel('True labels')
ax.set_title('Train Confusion Matrix')
ax.xaxis.set_ticklabels(['negative', 'positive'])
ax.yaxis.set_ticklabels(['negative', 'positive'])
```

Out[390]: [<matplotlib.text.Text at 0x403af1d0>, <matplotlib.text.Text at 0xd798ef0>]



In [0]:
```
ax= plt.subplot()
sns.heatmap(tfidfw2v_test_conf_matrix, annot=True, ax = ax, fmt='g')

ax.set_ylabel('Predicted labels')
ax.set_xlabel('True labels')
ax.set_title('Test Confusion Matrix')
ax.xaxis.set_ticklabels(['negative', 'positive'])
ax.yaxis.set_ticklabels(['negative', 'positive'])
```

Out[391]:
```
[<matplotlib.text.Text at 0x3dfd7940>, <matplotlib.text.Text at 0x343f8d30>]
```



RBF Kernel

In [0]:
```
#Data

X_train = X[0:20000]
Y_train = y[0:20000]
X_val = X[20000:25000]
Y_val = y[20000:25000]
X_test = X[25000:30000]
Y_test = y[25000:30000]
```

In [15]:
```
print(len(X_train), len(X_test), len(X_val))
print(len(Y_train), len(Y_test), len(Y_val))
```

```
20000 5000 5000
20000 5000 5000
```

BoW on 20k

In [33]:
```
from sklearn.feature_extraction.text import CountVectorizer

count_vect = CountVectorizer()
X_train_vect = count_vect.fit_transform(X_train)
X_test_vect = count_vect.transform(X_test)
X_val_vect = count_vect.transform(X_val)
feature_names = count_vect.get_feature_names()
# BoW_dict = {'X_train_vect':X_train_vect, 'X_test_vect': X_test_vect, 'X_val_vec
print(X_train_vect.shape)
# print(feature_names)
```

```
(20000, 29706)
```

In [0]:
```
from scipy.sparse import hstack
# len_review = final['lengthOfReview'].to_sparse()
concat_data = hstack((X_train_vect,np.array(final['lengthOfReview'][0:20000])[:,N
concat_data_val = hstack((X_val_vect,np.array(final['lengthOfReview'][20000:25000
concat_data_test = hstack((X_test_vect,np.array(final['lengthOfReview'][25000:300
```

In [36]:
```
print(concat_data.shape)
print(concat_data_val.shape)
print(concat_data_test.shape)
```

```
(20000, 29707)
(5000, 29707)
(5000, 29707)
```

In [37]:
```
BoW_dict = {'X_train_vect':concat_data, 'X_test_vect': concat_data_test, 'X_val_v
print(BoW_dict['X_train_vect'].shape)
```

```
(20000, 29707)
```

In [0]:
```
import pickle
with open('/content/gdrive/My Drive/Colab Notebooks/SVM/30kBoW.pkl', 'wb') as han
    pickle.dump(BoW_dict, handle, protocol=pickle.HIGHEST_PROTOCOL)
```

[4.3] TF-IDF

In [39]:
```
tf_idf_vect = TfidfVectorizer(ngram_range=(1,2), min_df=10, max_features=500)
train_tf_idf = tf_idf_vect.fit_transform(X_train)
cv_tf_idf = tf_idf_vect.transform(X_val)
test_tf_idf = tf_idf_vect.transform(X_test)

print("the shape of out text TFIDF vectorizer ",train_tf_idf.get_shape())
print("the type of count vectorizer ",type(train_tf_idf))
print("the number of unique words including both unigrams and bigrams ", train_tf
```

```
the shape of out text TFIDF vectorizer  (20000, 500)
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the number of unique words including both unigrams and bigrams  500
```

In [0]:
```
tfidf_concat_data_train = hstack((train_tf_idf,np.array(final['lengthOfReview'][0
tfidf_concat_data_val = hstack((cv_tf_idf,np.array(final['lengthOfReview'][20000:
tfidf_concat_data_test = hstack((test_tf_idf,np.array(final['lengthOfReview'][250
```

In [0]:
```
tf_idf_dict = {'train_tf_idf': tfidf_concat_data_train, 'cv_tf_idf': tfidf_concat
```

In [0]:
```
import pickle
with open('/content/gdrive/My Drive/Colab Notebooks/SVM/30ktf_idf.pkl', 'wb') as
    pickle.dump(tf_idf_dict, handle, protocol=pickle.HIGHEST_PROTOCOL)
```

[4.4] Word2Vec

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

In [17]:
```
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(list_of_sen,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-negative3
        print(w2v_model.wv.most_similar('great'))
        print(w2v_model.wv.most_similar('worst'))
    else:
        print("you don't have gogole's word2vec file, keep want_to_train_w2v = Tr
```

```
[('wonderful', 0.9070028066635132), ('good', 0.8153142929077148), ('perfect',
0.7934567332267761), ('nice', 0.7591120600700378), ('fantastic', 0.732208073139
1907), ('delicious', 0.7165140509605408), ('special', 0.6991521120071411), ('ex
cellent', 0.6706159710884094), ('decent', 0.6646473407745361), ('great.', 0.659
8770022392273)]
==================================================
[('best.', 0.8320965766906738), ('best', 0.8228322267532349), ('best-tasting',
0.8215420842170715), ('nicest', 0.810248076915741), ('greatest', 0.796181023120
8801), ('best!', 0.7789650559425354), ('had.', 0.7666232585906982), ('Best', 0.
7660649418830872), ('tried.', 0.7629457116127014), ('made.', 0.75928080081939
7)]
```

In [18]:
```
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  16103
sample words  ['EVERY', 'book', 'is', 'this', 'little', 'makes', 'my', 'son',
'laugh', 'at', 'i', 'it', 'in', 'the', 'car', 'as', "we're", 'driving', 'alon
g', 'and', 'he', 'always', 'can', 'sing', "he's", 'learned', 'about', 'India,',
'love', 'all', 'new', 'words', 'of', 'all.', 'a', 'classic', 'am', 'willing',
'to', 'bet', 'will', 'STILL', 'be', 'able', 'from', 'memory', 'when', 'colleg
e', 'This', 'whole']
```

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

[4.4.1.1] Avg W2v

In [19]:
```
print(X_train[117924])
print(len(X_val))
print(len(X_test))
```

```
EVERY book is educational. this witty little book makes my son laugh at loud. i
recite it in the car as we're driving along and he always can sing the refrain.
he's learned about whales, India, drooping roses:  i love all the new words thi
s book  introduces and the silliness of it all.  this is a classic book i am  w
illing to bet my son will STILL be able to recite from memory when he is  in co
llege
5000
5000
```

In [0]:
```
# average Word2Vec
# compute average word2vec for each review.
def avg_w2vec(sentences_received):
    sent_vectors = []; # the avg-w2v for each sentence/review is stored in this l
    for sent in tqdm(sentences_received): # for each review/sentence
        sent_vec = np.zeros(50) # as word vectors are of zero length 50, you migh
        cnt_words =0; # num of words with a valid vector in the sentence/review
        for word in sent: # for each word in a review/sentence
            if word in w2v_words:
                vec = w2v_model.wv[word]
                sent_vec += vec
                cnt_words += 1
        if cnt_words != 0:
            sent_vec /= cnt_words
        sent_vectors.append(sent_vec)

    print(len(sent_vectors))
    print(len(sent_vectors[0]))
    return sent_vectors
```

In [21]:
```
print(len([sent.split() for sent in X_test]))
```

```
5000
```

In [22]:
```
avg_w2v_train = avg_w2vec([sent.split() for sent in X_train])
avg_w2v_cv = avg_w2vec([sent.split() for sent in X_val])
avg_w2v_test = avg_w2vec([sent.split() for sent in X_test])
```

```
100%|██████████| 20000/20000 [01:54<00:00, 175.21it/s]
  1%|          | 28/5000 [00:00<00:17, 276.46it/s]

20000
50

100%|██████████| 5000/5000 [00:27<00:00, 183.63it/s]
  0%|          | 25/5000 [00:00<00:20, 247.93it/s]

5000
50

100%|██████████| 5000/5000 [00:30<00:00, 165.08it/s]

5000
50
```

In [0]:
```
Avg_w2v_dict = {'X_train_avgw2v':avg_w2v_train, 'Y_train_avgw2v': Y_train,
                    'X_val_avgw2v': avg_w2v_cv, 'Y_val_avgw2v': Y_val,
                   'X_test_avgw2v': avg_w2v_test, 'Y_test_avgw2v': Y_test}
```

In [0]:
```
import pickle
with open('/content/gdrive/My Drive/Colab Notebooks/SVM/30kavg_w2v.pkl', 'wb') as
    pickle.dump(Avg_w2v_dict, handle, protocol=pickle.HIGHEST_PROTOCOL)
```

TFIDF-w2v

In [0]:
```
# S = ["abc def pqr", "def def def abc", "pqr pqr def"]
model = TfidfVectorizer(min_df=10, max_features=500)
tf_idf_matrix = model.fit_transform(X_train)
# we are converting a dictionary with word as a key, and the idf as a value
dictionary = dict(zip(model.get_feature_names(), list(model.idf_)))
```

In [0]:
```
# TF-IDF weighted Word2Vec
tfidf_feat = model.get_feature_names() # tfidf words/col-names
# final_tf_idf is the sparse matrix with row= sentence, col=word and cell_val = t

def tfidf_w2v(sentences_received):
    tfidf_sent_vectors = []; # the tfidf-w2v for each sentence/review is stored i
    row=0;
    for sent in tqdm(sentences_received): # 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.append(sent_vec)
        row += 1

    return tfidf_sent_vectors
```

In [46]:
```
tfidf_w2v_train = tfidf_w2v([sent.split() for sent in X_train])
tfidf_w2v_cv = tfidf_w2v([sent.split() for sent in X_val])
tfidf_w2v_test = tfidf_w2v([sent.split() for sent in X_test])
```

```
100%|██████████| 20000/20000 [02:07<00:00, 156.36it/s]
100%|██████████| 5000/5000 [00:29<00:00, 168.92it/s]
100%|██████████| 5000/5000 [00:34<00:00, 145.98it/s]
```

In [0]:
```
tfidf_w2v_dict = {'X_train_tfidfw2v':tfidf_w2v_train, 'Y_train_tfidfw2v': Y_train
                     'X_val_tfidfw2v': tfidf_w2v_cv, 'Y_val_tfidfw2v': Y_val,
                    'X_test_tfidfw2v': tfidf_w2v_test, 'Y_test_tfidfw2v': Y_test}
```

In [0]:
```
with open('/content/gdrive/My Drive/Colab Notebooks/SVM/30ktfidf_w2v.pkl', 'wb') 
    pickle.dump(tfidf_w2v_dict, handle, protocol=pickle.HIGHEST_PROTOCOL)
```

SVM on BoW (RBF)

In [0]:
```
from sklearn.svm import SVC
```

In [0]:
```
import pickle
with open(r"/content/gdrive/My Drive/Colab Notebooks/SVM/30kBoW.pkl", "rb") as in
    BoW_dict = pickle.load(input_file)
```

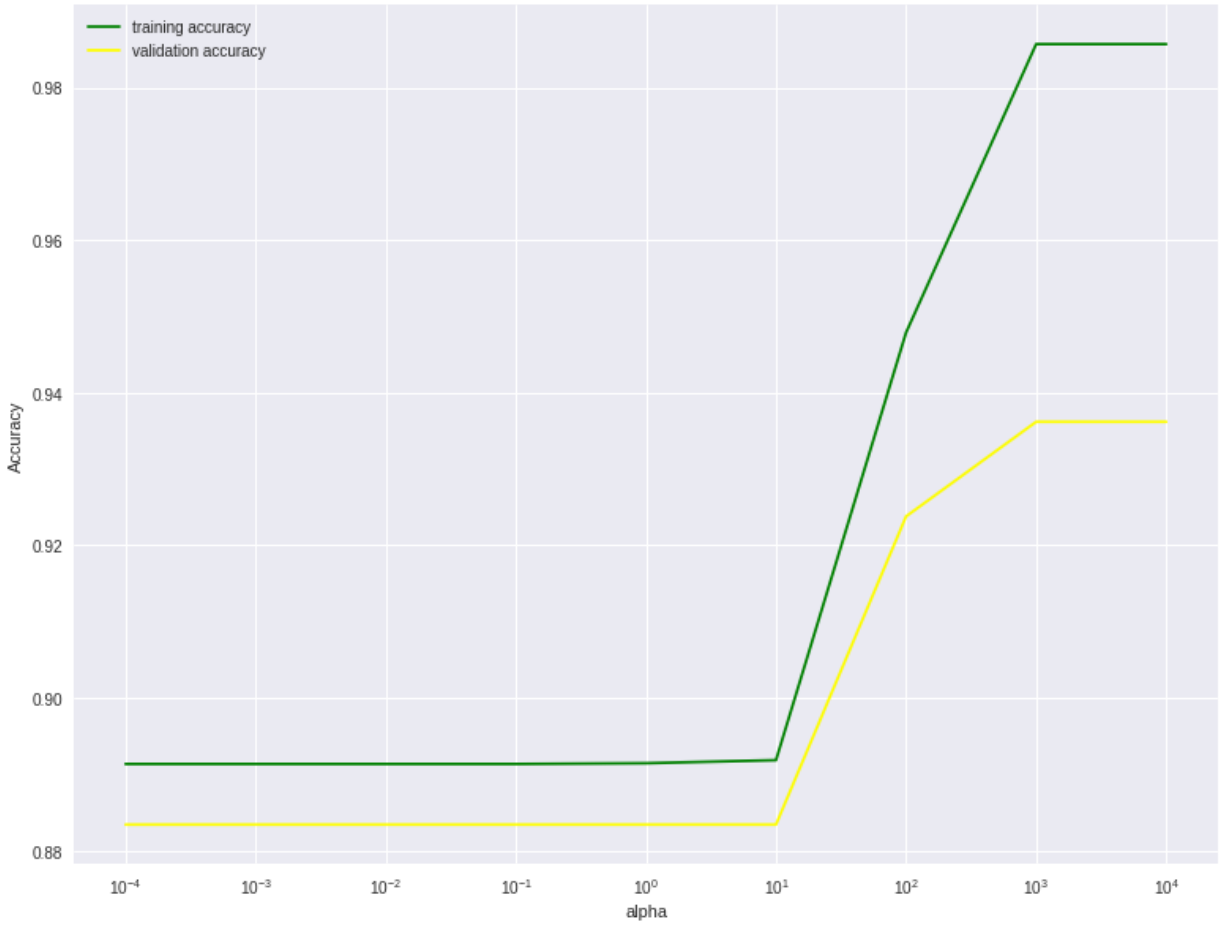
In [51]:
```
#Applying Logistic Regression with L1 regularization on BOW
from sklearn.linear_model import LogisticRegression
from tqdm import tqdm

bow_svm_train_score_list = []
bow_svm_val_score_list = []
for c_value in tqdm([0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 1000]):
    bow_clf = SVC(C=c_value, kernel='rbf')
    bow_clf.fit(BoW_dict['X_train_vect'],Y_train)

    bow_clf_train_score = bow_clf.score(BoW_dict['X_train_vect'], Y_train)
    bow_svm_train_score_list.append(bow_clf_train_score)
    bow_clf_val_score = bow_clf.score(BoW_dict['X_val_vect'], Y_val)
    bow_svm_val_score_list.append(bow_clf_val_score)

c_all = [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
bow_train_score = dict(zip(c_all, bow_svm_train_score_list))
bow_val_score = dict(zip(c_all, bow_svm_val_score_list))
print(bow_train_score)
print(bow_val_score)
```

```
100%|██████████| 9/9 [21:20<00:00, 151.09s/it]

{0.0001: 0.89135, 0.001: 0.89135, 0.01: 0.89135, 0.1: 0.89135, 1: 0.89145, 10:
0.89185, 100: 0.9479, 1000: 0.9857, 10000: 0.9857}
{0.0001: 0.8834, 0.001: 0.8834, 0.01: 0.8834, 0.1: 0.8834, 1: 0.8834, 10: 0.883
4, 100: 0.9238, 1000: 0.9362, 10000: 0.9362}
```

In [52]:
```
best_c = max(bow_val_score, key=bow_val_score.get)
best_c
```

Out[52]: 1000

In [53]:
```
import pylab
plt.figure(figsize=(13, 10))
neighbors_settings = [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
plt.plot(neighbors_settings, bow_svm_train_score_list, label="training accuracy",
plt.plot(neighbors_settings, bow_svm_val_score_list, label="validation accuracy",
# plt.plot(neighbors_settings, auc_test, label="test accuracy", color='red')
plt.xlabel('alpha')
plt.ylabel('Accuracy')
plt.legend()
plt.xscale('log')

plt.show()
```



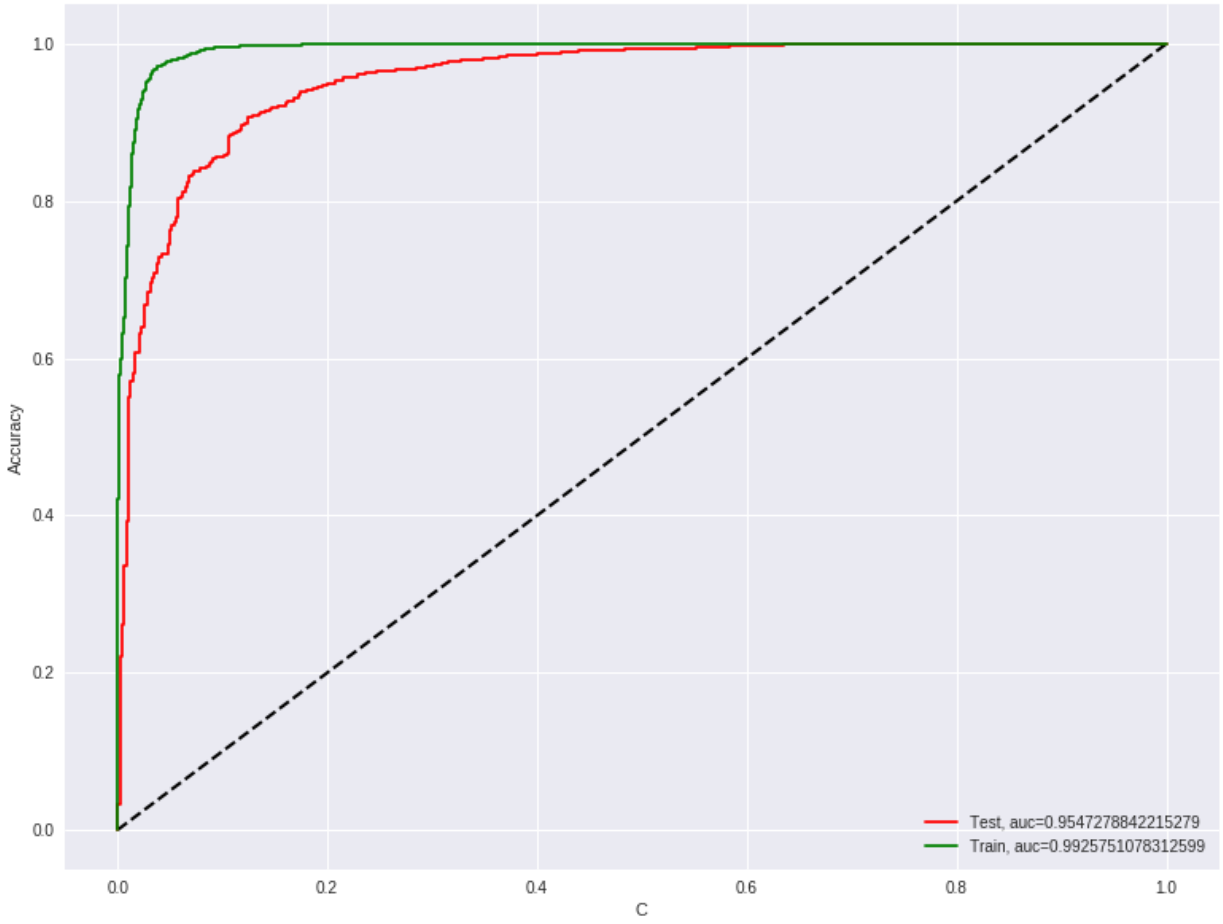
In [54]:
```
bow_svm_linear=SVC(C=best_c, kernel='rbf')
bow_svm_linear.fit(BoW_dict['X_train_vect'],Y_train)
f = CalibratedClassifierCV(base_estimator=bow_svm_linear)
f.fit(BoW_dict['X_train_vect'],Y_train)
bow_linear_test_proba = f.predict_proba(BoW_dict['X_test_vect'])
bow_linear_train_proba = f.predict_proba(BoW_dict['X_train_vect'])
bow_linear_test_proba
```

Out[54]:
```
array([[0.1148381 , 0.8851619 ],
       [0.05897012, 0.94102988],
       [0.03864145, 0.96135855],
       ...,
       [0.02261815, 0.97738185],
       [0.02777235, 0.97222765],
       [0.1101549 , 0.8898451 ]])
```

In [55]:
```
bow_fpr_train, bow_tpr_train, _ = roc_curve(Y_train, bow_linear_train_proba[:, 1]
bow_fpr_test, bow_tpr_test, _ = roc_curve(Y_test, bow_linear_test_proba[:, 1])
bow_test_auc = auc(bow_fpr_test, bow_tpr_test)
bow_train_auc = auc(bow_fpr_train, bow_tpr_train)
print(bow_test_auc)
print(bow_train_auc)
```

```
0.9547278842215279
0.9925751078312599
```

In [56]:
```
import pylab
plt.figure(figsize=(13, 10))
plt.plot([0,1], [0,1], color='black', lw=2, linestyle='--')
plt.plot(bow_fpr_test, bow_tpr_test, label="Test, auc="+str(bow_test_auc), color
plt.plot(bow_fpr_train, bow_tpr_train, label="Train, auc="+str(bow_train_auc), co

plt.xlabel('C')
plt.ylabel('Accuracy')
plt.legend()

plt.show()
```



In [0]:
```
bow_test_conf = bow_svm_linear.predict(BoW_dict['X_test_vect'])
```

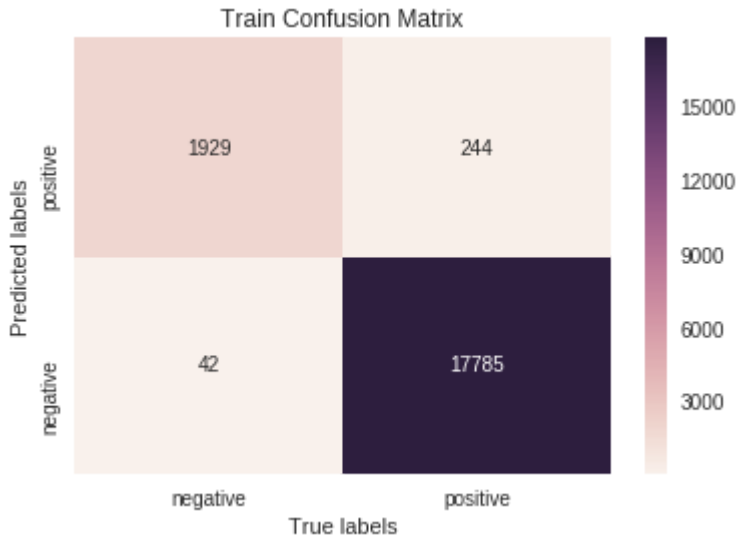
In [0]:
```
bow_train_conf = bow_svm_linear.predict(BoW_dict['X_train_vect'])
```

In [60]:
```
from sklearn.metrics import classification_report, confusion_matrix
bow_train_conf_matrix = confusion_matrix(Y_train, bow_train_conf)
bow_test_conf_matrix = confusion_matrix(Y_test, bow_test_conf)
class_report = classification_report(Y_test, bow_test_conf)
print(bow_test_conf_matrix)
print(class_report)
```

```
[[ 300  182]
 [  78 4440]]
              precision    recall  f1-score   support

           0       0.79      0.62      0.70       482
           1       0.96      0.98      0.97      4518

   micro avg       0.95      0.95      0.95      5000
   macro avg       0.88      0.80      0.83      5000
weighted avg       0.94      0.95      0.95      5000
```

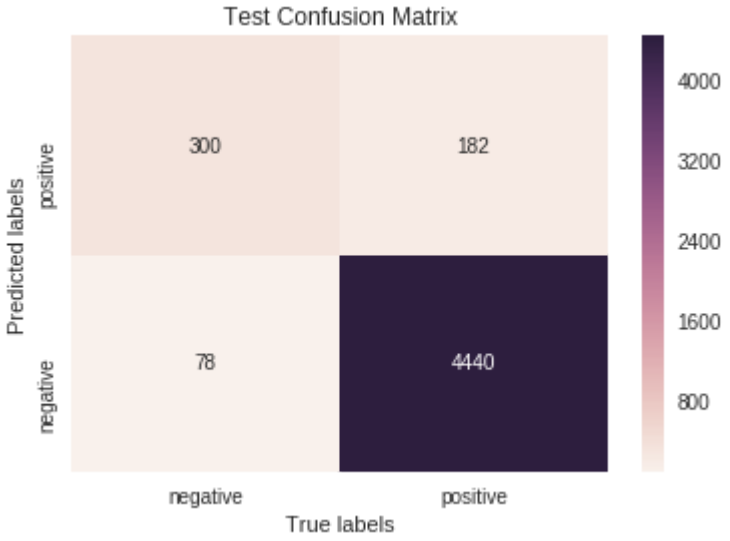
In [61]:
```
ax= plt.subplot()
sns.heatmap(bow_train_conf_matrix, annot=True, ax = ax, fmt='g')

ax.set_ylabel('Predicted labels')
ax.set_xlabel('True labels')
ax.set_title('Train Confusion Matrix')
ax.xaxis.set_ticklabels(['negative', 'positive'])
ax.yaxis.set_ticklabels(['negative', 'positive'])
```

Out[61]: [Text(0, 0.5, 'negative'), Text(0, 1.5, 'positive')]



In [62]:
```
ax= plt.subplot()
sns.heatmap(bow_test_conf_matrix, annot=True, ax = ax, fmt='g')

ax.set_ylabel('Predicted labels')
ax.set_xlabel('True labels')
ax.set_title('Test Confusion Matrix')
ax.xaxis.set_ticklabels(['negative', 'positive'])
ax.yaxis.set_ticklabels(['negative', 'positive'])
```

Out[62]:
```
[Text(0, 0.5, 'negative'), Text(0, 1.5, 'positive')]
```



SVM on TF-IDF (Linear)

In [0]:
```
import pickle
with open(r"/content/gdrive/My Drive/Colab Notebooks/SVM/30ktf_idf.pkl", "rb") as
    tfidf_dict = pickle.load(input_file)
```

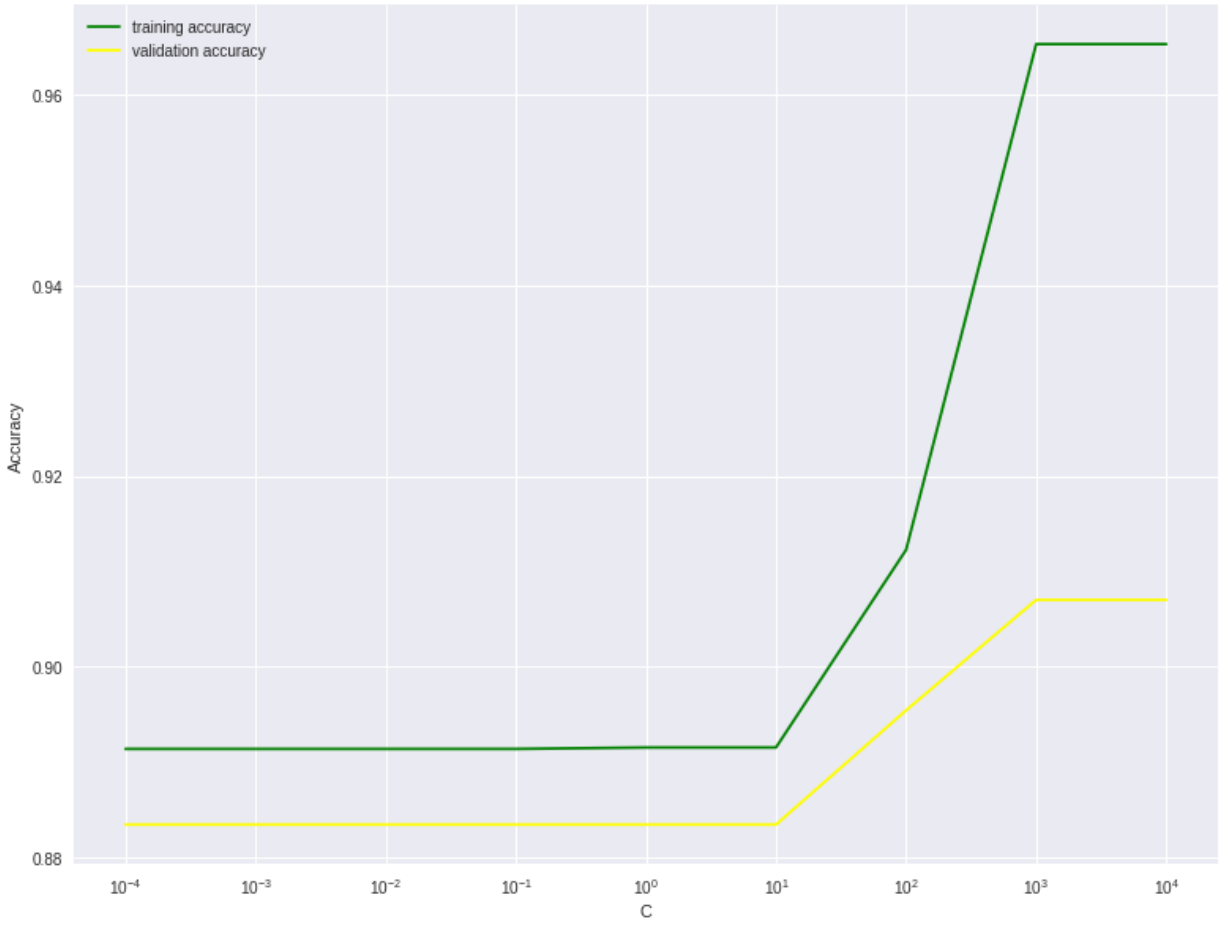
In [65]:
```
tfidf_svm_train_score_list = []
tfidf_svm_val_score_list = []
for c_value in tqdm([0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 1000]):
    tfidfclf = SVC(C=c_value, kernel='rbf')
    tfidfclf.fit(tfidf_dict['train_tf_idf'],Y_train)

    tfidf_svm_train_score = tfidfclf.score(tfidf_dict['train_tf_idf'], Y_train)
    tfidf_svm_train_score_list.append(tfidf_svm_train_score)
    tfidf_svm_val_score = tfidfclf.score(tfidf_dict['cv_tf_idf'], Y_val)
    tfidf_svm_val_score_list.append(tfidf_svm_val_score)

c_all = [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
tfidf_train_score = dict(zip(c_all, tfidf_svm_train_score_list))
tfidf_val_scores = dict(zip(c_all, tfidf_svm_val_score_list))
print(tfidf_train_score)
print(tfidf_val_scores)
```

```
100%|██████████| 9/9 [20:08<00:00, 158.74s/it]

{0.0001: 0.89135, 0.001: 0.89135, 0.01: 0.89135, 0.1: 0.89135, 1: 0.8915, 10:
0.8915, 100: 0.91225, 1000: 0.96535, 10000: 0.96535}
{0.0001: 0.8834, 0.001: 0.8834, 0.01: 0.8834, 0.1: 0.8834, 1: 0.8834, 10: 0.883
4, 100: 0.8954, 1000: 0.907, 10000: 0.907}
```

In [66]:
```
tfidf_best_c = max(tfidf_val_scores, key=tfidf_val_scores.get)
tfidf_best_c
```

Out[66]: 1000

In [67]:
```
import pylab
plt.figure(figsize=(13, 10))
neighbors_settings = [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
plt.plot(neighbors_settings, tfidf_svm_train_score_list, label="training accuracy
plt.plot(neighbors_settings, tfidf_svm_val_score_list, label="validation accuracy
# plt.plot(neighbors_settings, auc_test, label="test accuracy", color='red')
plt.xlabel('C')
plt.ylabel('Accuracy')
plt.legend()
plt.xscale('log')

plt.show()
```



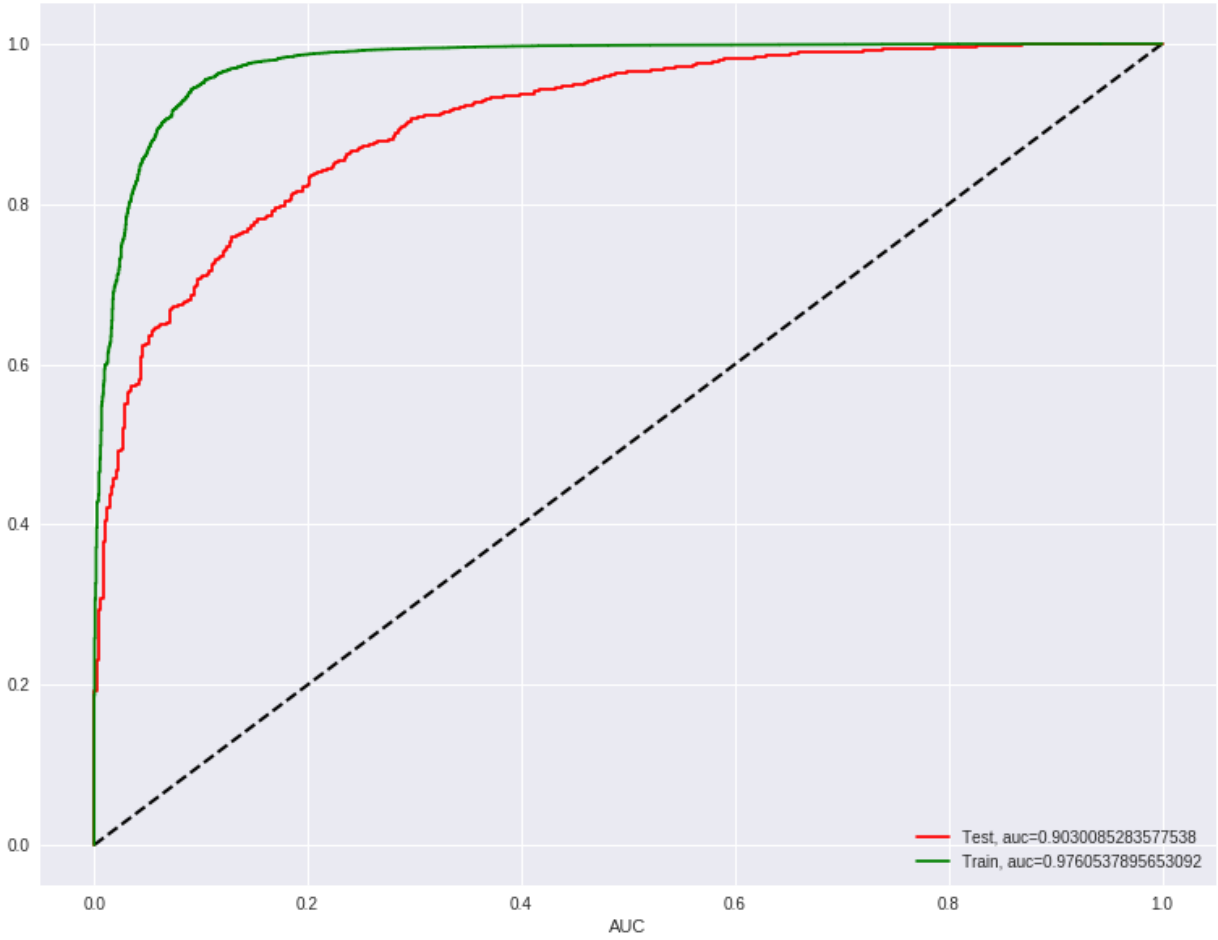
In [69]:
```
tfidf_svm_linear=SVC(C=tfidf_best_c, kernel='rbf')
tfidf_svm_linear.fit(tfidf_dict['train_tf_idf'], Y_train)
f = CalibratedClassifierCV(base_estimator=bow_svm_linear)
f.fit(tfidf_dict['train_tf_idf'], Y_train)
tfidf_linear_test_proba = f.predict_proba(tfidf_dict['test_tf_idf'])
tfidf_linear_train_proba = f.predict_proba(tfidf_dict['train_tf_idf'])
tfidf_linear_test_proba
```

Out[69]:
```
array([[0.06192611, 0.93807389],
       [0.05750108, 0.94249892],
       [0.09716267, 0.90283733],
       ...,
       [0.06753958, 0.93246042],
       [0.01556645, 0.98443355],
       [0.13025602, 0.86974398]])
```

In [70]:
```
tfidf_fpr_train, tfidf_tpr_train, _ = roc_curve(Y_train, tfidf_linear_train_proba
tfidf_fpr_test, tfidf_tpr_test, _ = roc_curve(Y_test, tfidf_linear_test_proba[:,
tfidf_test_auc = auc(tfidf_fpr_test, tfidf_tpr_test)
tfidf_train_auc = auc(tfidf_fpr_train, tfidf_tpr_train)
print(tfidf_test_auc)
print(tfidf_train_auc)
```

```
0.9030085283577538
0.9760537895653092
```

In [71]:
```
import pylab
plt.figure(figsize=(13, 10))
plt.plot([0,1], [0,1], color='black', lw=2, linestyle='--')
plt.plot(tfidf_fpr_test, tfidf_tpr_test, label="Test, auc="+str(tfidf_test_auc),
plt.plot(tfidf_fpr_train, tfidf_tpr_train, label="Train, auc="+str(tfidf_train_au

plt.xlabel('AUC')
plt.legend()

plt.show()
```



In [0]:
```
tfidf_test_conf = tfidf_svm_linear.predict(tfidf_dict['test_tf_idf'])
```

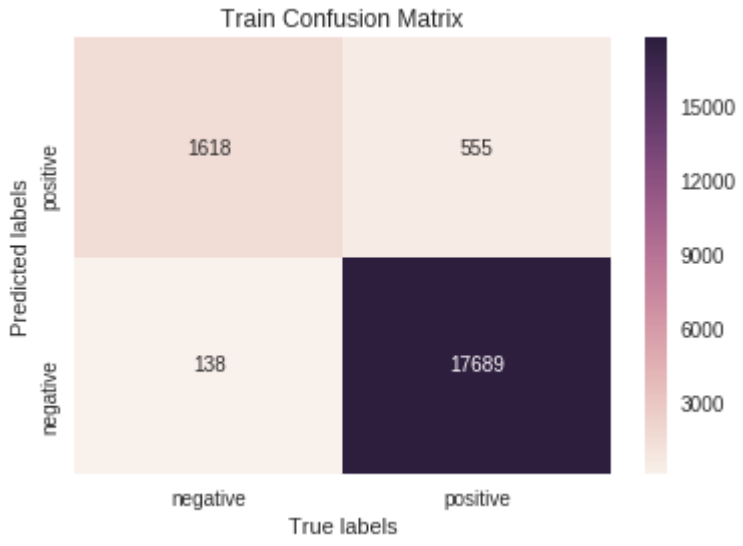
In [0]:
```
tfidf_train_conf = tfidf_svm_linear.predict(tfidf_dict['train_tf_idf'])
```

In [74]:
```
from sklearn.metrics import classification_report, confusion_matrix
tfidf_test_conf_matrix = confusion_matrix(Y_test, tfidf_test_conf)
tfidf_train_conf_matrix = confusion_matrix(Y_train, tfidf_train_conf)
class_report = classification_report(Y_test, tfidf_test_conf)
print(tfidf_test_conf_matrix)
print(class_report)
```

```
[[ 200  282]
 [ 127 4391]]
              precision    recall  f1-score   support

           0       0.61      0.41      0.49       482
           1       0.94      0.97      0.96      4518

   micro avg       0.92      0.92      0.92      5000
   macro avg       0.78      0.69      0.72      5000
weighted avg       0.91      0.92      0.91      5000
```

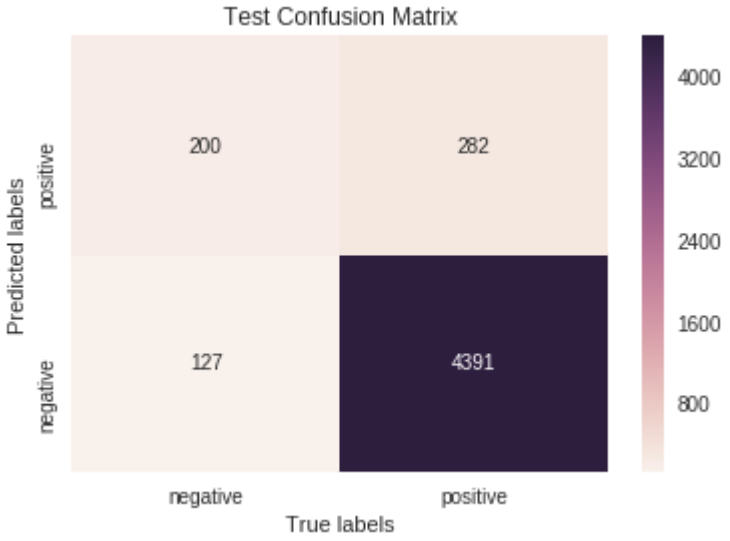
In [75]:
```
ax= plt.subplot()
sns.heatmap(tfidf_train_conf_matrix, annot=True, ax = ax, fmt='g')

ax.set_ylabel('Predicted labels')
ax.set_xlabel('True labels')
ax.set_title('Train Confusion Matrix')
ax.xaxis.set_ticklabels(['negative', 'positive'])
ax.yaxis.set_ticklabels(['negative', 'positive'])
```

Out[75]: [Text(0, 0.5, 'negative'), Text(0, 1.5, 'positive')]



In [76]:
```
ax= plt.subplot()
sns.heatmap(tfidf_test_conf_matrix, annot=True, ax = ax, fmt='g')

ax.set_ylabel('Predicted labels')
ax.set_xlabel('True labels')
ax.set_title('Test Confusion Matrix')
ax.xaxis.set_ticklabels(['negative', 'positive'])
ax.yaxis.set_ticklabels(['negative', 'positive'])
```

Out[76]:
```
[Text(0, 0.5, 'negative'), Text(0, 1.5, 'positive')]
```



SVM on Avg-W2V

In [0]:
```
import pickle
with open(r"/content/gdrive/My Drive/Colab Notebooks/SVM/30kavg_w2v.pkl", "rb") a
    avg_tfidf_dict = pickle.load(input_file)
```

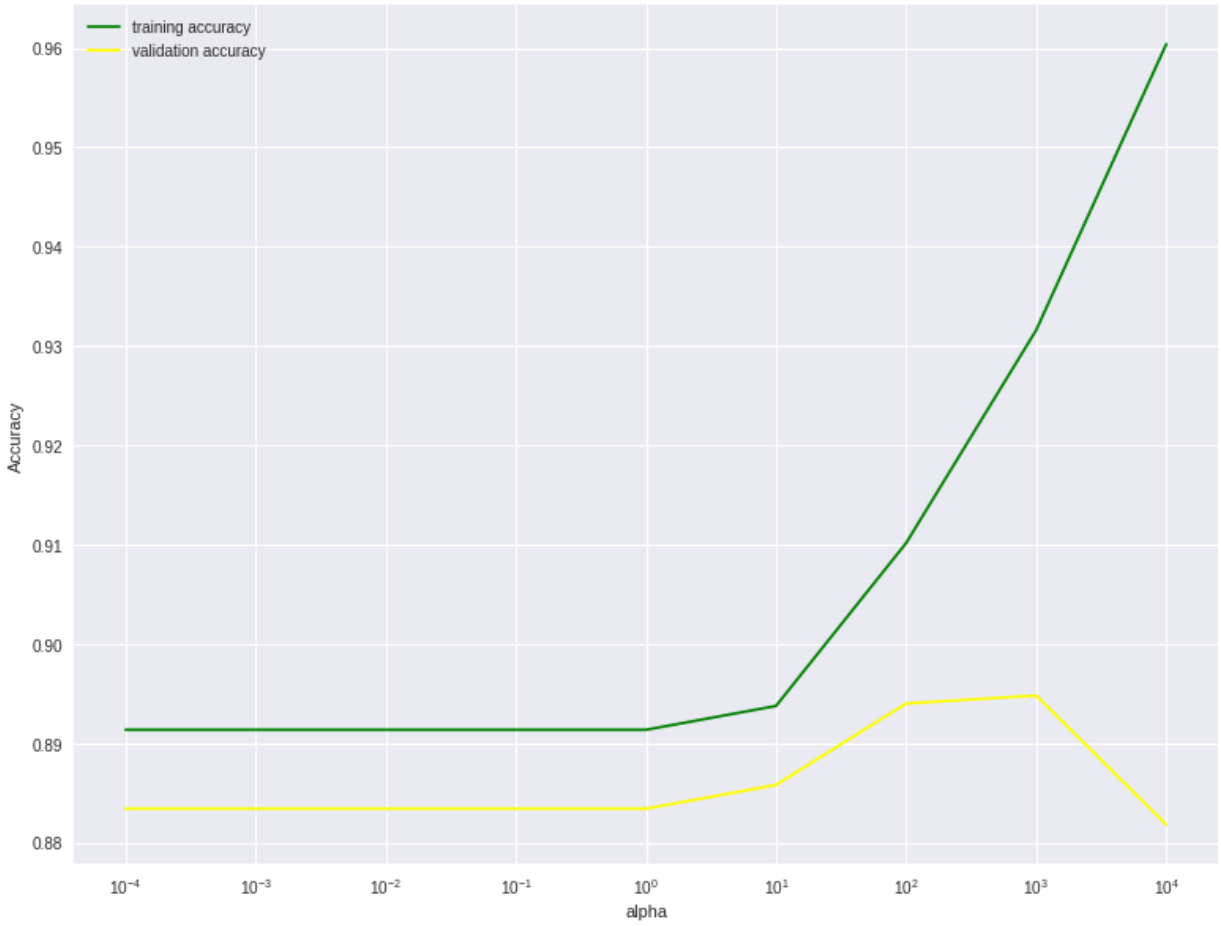
In [79]:
```
avg_lgr_train_score_list = []
avg_lgr_val_score_list = []
for c_value in tqdm([0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]):
    avg_lgr=SVC(C=c_value, kernel='rbf')
    avg_lgr.fit(avg_tfidf_dict['X_train_avgw2v'],Y_train)

    avg_lgr_train_score = avg_lgr.score(avg_tfidf_dict['X_train_avgw2v'], Y_train
    avg_lgr_train_score_list.append(avg_lgr_train_score)
    avg_lgr_val_score = avg_lgr.score(avg_tfidf_dict['X_val_avgw2v'], Y_val)
    avg_lgr_val_score_list.append(avg_lgr_val_score)

c_all = [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
avg_train_score = dict(zip(c_all, avg_lgr_train_score_list))
avg_val_score = dict(zip(c_all, avg_lgr_val_score_list))
print(avg_train_score)
print(avg_val_score)
```

```
100%|██████████| 9/9 [14:28<00:00, 207.91s/it]

{0.0001: 0.89135, 0.001: 0.89135, 0.01: 0.89135, 0.1: 0.89135, 1: 0.89135, 10:
0.89375, 100: 0.91015, 1000: 0.9316, 10000: 0.9604}
{0.0001: 0.8834, 0.001: 0.8834, 0.01: 0.8834, 0.1: 0.8834, 1: 0.8834, 10: 0.885
8, 100: 0.894, 1000: 0.8948, 10000: 0.8818}
```

In [85]:
```
best_c = max(avg_val_score, key=avg_val_score.get)
best_c
```

Out[85]: 1000

In [86]:
```
import pylab
plt.figure(figsize=(13, 10))
neighbors_settings = [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
plt.plot(neighbors_settings, avg_lgr_train_score_list, label="training accuracy",
plt.plot(neighbors_settings, avg_lgr_val_score_list, label="validation accuracy",
# plt.plot(neighbors_settings, auc_test, label="test accuracy", color='red')
plt.xlabel('alpha')
plt.ylabel('Accuracy')
plt.legend()
plt.xscale('log')

plt.show()
```



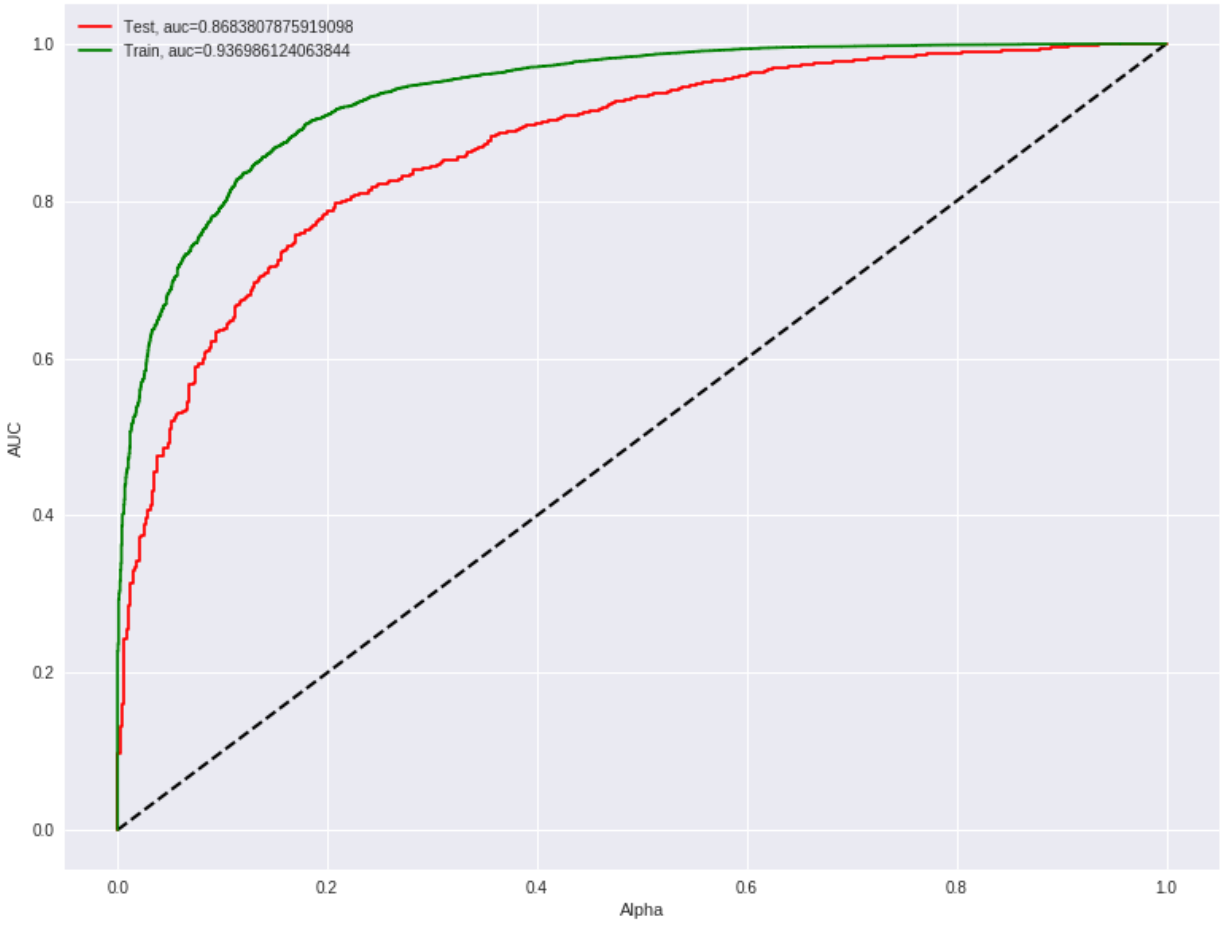
In [87]:
```
avg_svm_linear=SVC(C=best_c, kernel='rbf')
avg_svm_linear.fit(avg_tfidf_dict['X_train_avgw2v'], Y_train)
f = CalibratedClassifierCV(base_estimator=bow_svm_linear)
f.fit(avg_tfidf_dict['X_train_avgw2v'], Y_train)
avg_linear_test_proba = f.predict_proba(avg_tfidf_dict['X_test_avgw2v'])
avg_linear_train_proba = f.predict_proba(avg_tfidf_dict['X_train_avgw2v'])
avg_linear_test_proba
```

Out[87]:
```
array([[0.08696042, 0.91303958],
       [0.19738614, 0.80261386],
       [0.31957795, 0.68042205],
       ...,
       [0.06537385, 0.93462615],
       [0.05504791, 0.94495209],
       [0.09057401, 0.90942599]])
```

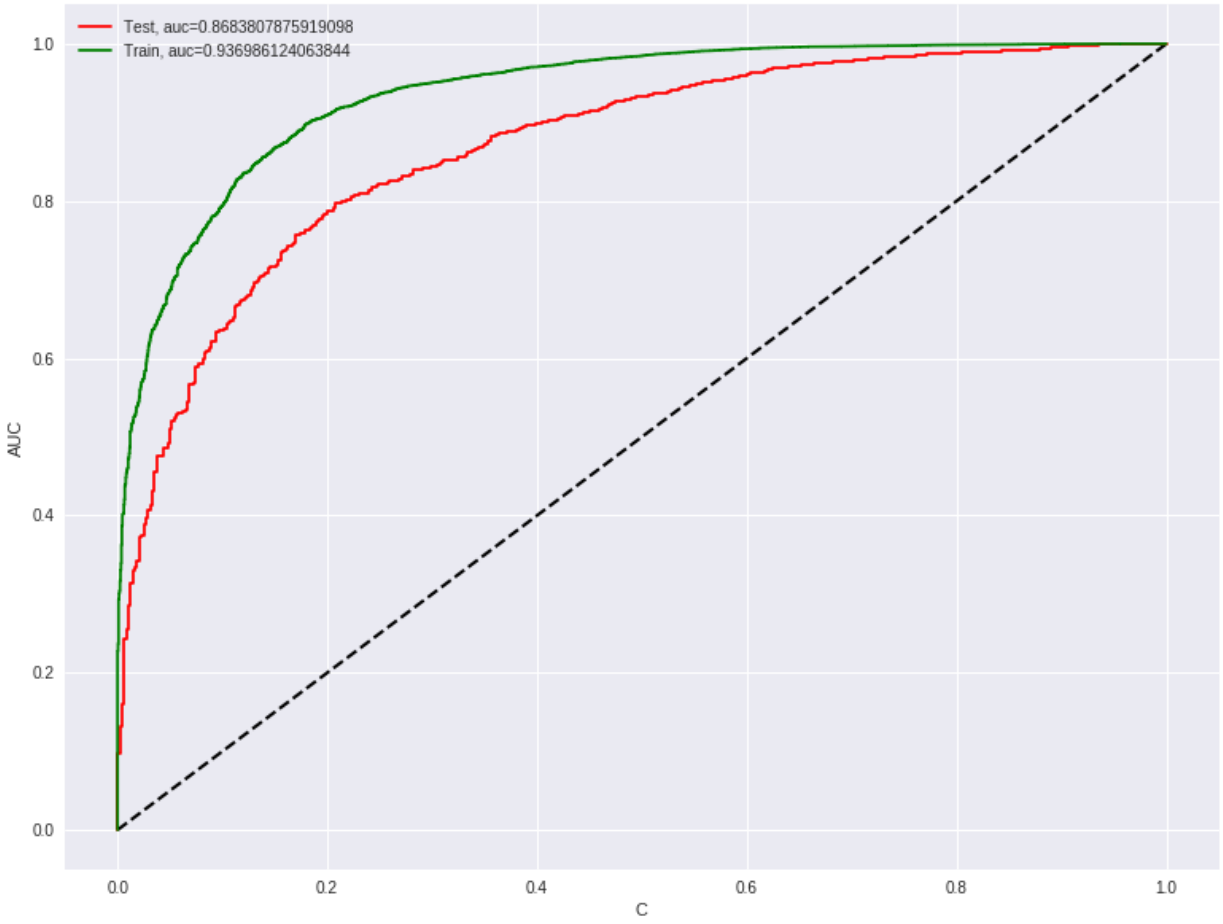
In [88]:
```
avg_fpr_train, avg_tpr_train, _ = roc_curve(Y_train, avg_linear_train_proba[:, 1]
avg_fpr_test, avg_tpr_test, _ = roc_curve(Y_test, avg_linear_test_proba[:, 1])
avg_test_auc = auc(avg_fpr_test, avg_tpr_test)
avg_train_auc = auc(avg_fpr_train, avg_tpr_train)
print(avg_test_auc)
print(avg_train_auc)
```

```
0.8683807875919098
0.936986124063844
```

In [89]:
```
import pylab
plt.figure(figsize=(13, 10))
plt.plot([0,1], [0,1], color='black', lw=2, linestyle='--')
plt.plot(avg_fpr_test, avg_tpr_test, label="Test, auc="+str(avg_test_auc), color =
plt.plot(avg_fpr_train, avg_tpr_train, label="Train, auc="+str(avg_train_auc), co

plt.xlabel('Alpha')
plt.ylabel('AUC')
plt.legend()

plt.show()
```



In [91]:
```
import pylab
plt.figure(figsize=(13, 10))
plt.plot([0,1], [0,1], color='black', lw=2, linestyle='--')
plt.plot(avg_fpr_test, avg_tpr_test, label="Test, auc="+str(avg_test_auc), color =
plt.plot(avg_fpr_train, avg_tpr_train, label="Train, auc="+str(avg_train_auc), co

plt.xlabel('C')
plt.ylabel('AUC')
plt.legend()

plt.show()
```



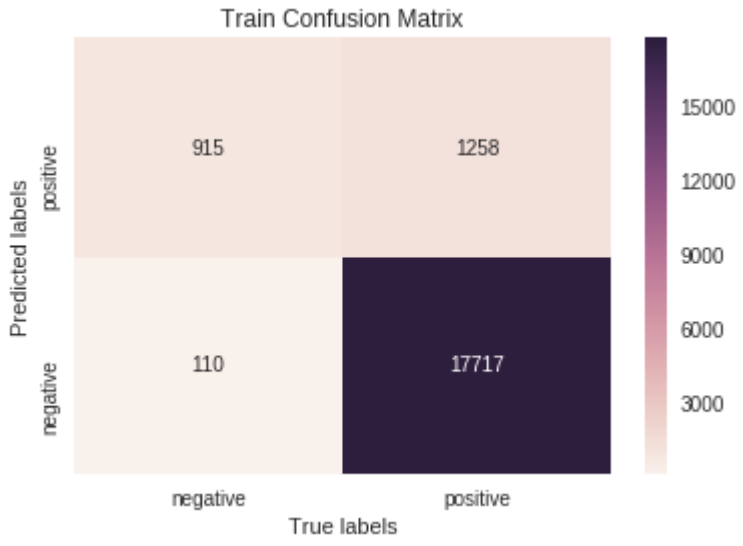
In [0]:
```
avg_test_conf = avg_svm_linear.predict(avg_tfidf_dict['X_test_avgw2v'])
avg_train_conf = avg_svm_linear.predict(avg_tfidf_dict['X_train_avgw2v'])
```

In [93]:
```
from sklearn.metrics import classification_report, confusion_matrix
avg_test_conf_matrix = confusion_matrix(Y_test, avg_test_conf)
avg_train_conf_matrix = confusion_matrix(Y_train, avg_train_conf)
class_report = classification_report(Y_test, avg_test_conf)
print(avg_test_conf_matrix)
print(class_report)
```

```
[[ 132  350]
 [  89 4429]]
              precision    recall  f1-score   support

           0       0.60      0.27      0.38       482
           1       0.93      0.98      0.95      4518

   micro avg       0.91      0.91      0.91      5000
   macro avg       0.76      0.63      0.66      5000
weighted avg       0.90      0.91      0.90      5000
```

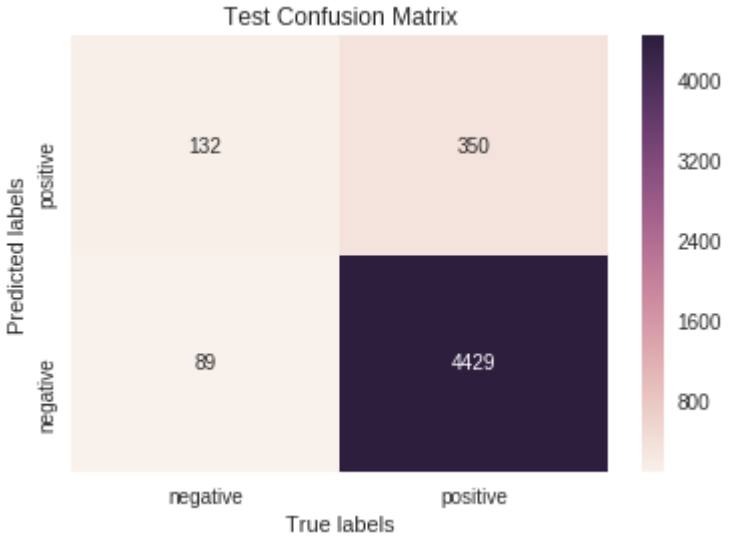
In [94]:
```
ax= plt.subplot()
sns.heatmap(avg_train_conf_matrix, annot=True, ax = ax, fmt='g')

ax.set_ylabel('Predicted labels')
ax.set_xlabel('True labels')
ax.set_title('Train Confusion Matrix')
ax.xaxis.set_ticklabels(['negative', 'positive'])
ax.yaxis.set_ticklabels(['negative', 'positive'])
```

Out[94]: [Text(0, 0.5, 'negative'), Text(0, 1.5, 'positive')]



In [95]:
```
ax= plt.subplot()
sns.heatmap(avg_test_conf_matrix, annot=True, ax = ax, fmt='g')

ax.set_ylabel('Predicted labels')
ax.set_xlabel('True labels')
ax.set_title('Test Confusion Matrix')
ax.xaxis.set_ticklabels(['negative', 'positive'])
ax.yaxis.set_ticklabels(['negative', 'positive'])
```

Out[95]:
```
[Text(0, 0.5, 'negative'), Text(0, 1.5, 'positive')]
```



SVM on tfidf_w2v (RBF)

In [0]:
```
import pickle
with open(r"/content/gdrive/My Drive/Colab Notebooks/SVM/30ktfidf_w2v.pkl", "rb")
    tfidfw2v_dict = pickle.load(input_file)
```

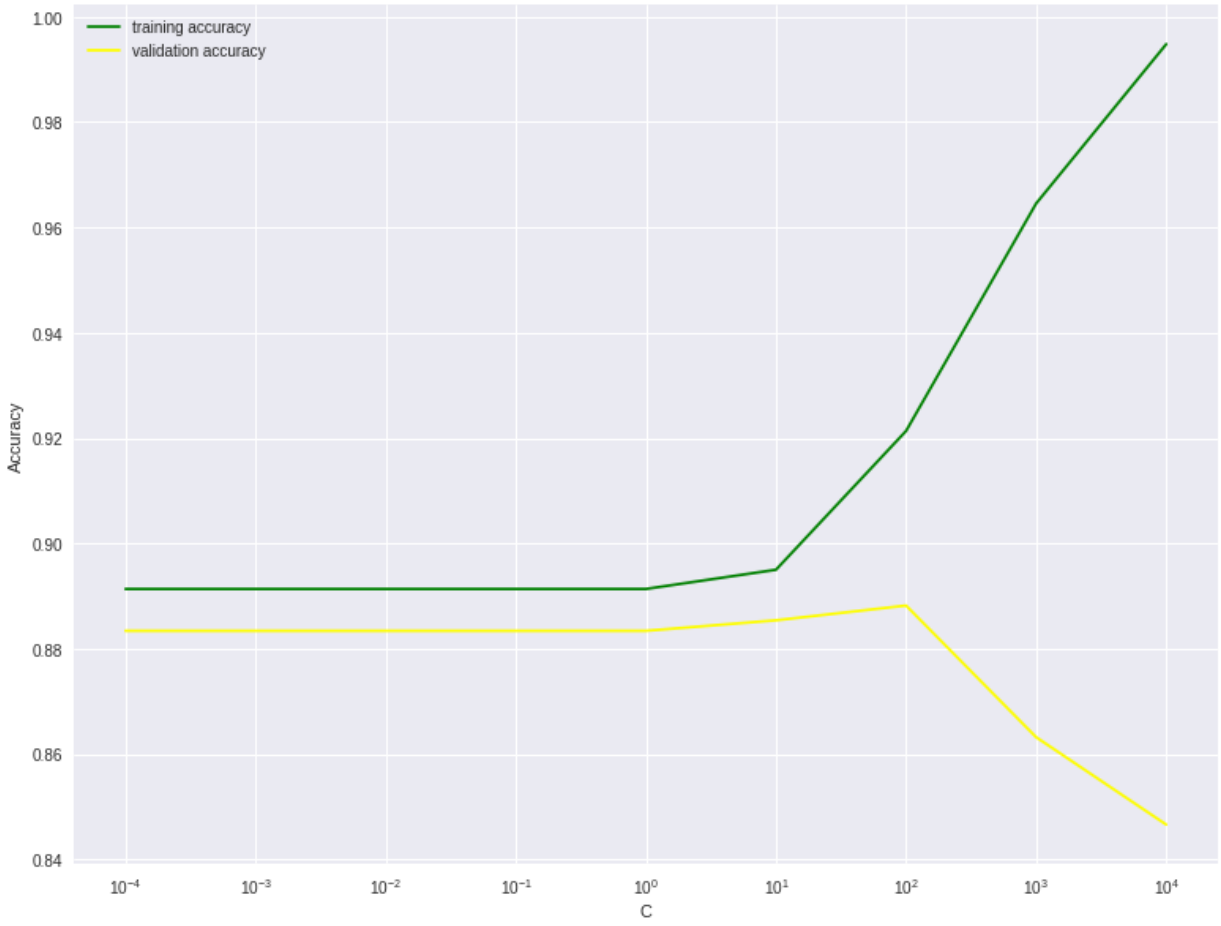
In [98]:
```
from sklearn.linear_model import LogisticRegression
from tqdm import tqdm

tfidfw2v_lgr_train_score_list = []
tfidfw2v_lgr_val_score_list = []
for c_value in tqdm([0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]):
    tfidfw2v_lgr=SVC(C=c_value, kernel='rbf')
    tfidfw2v_lgr.fit(tfidfw2v_dict['X_train_tfidfw2v'],Y_train)

    tfidfw2v_lgr_train_score = tfidfw2v_lgr.score(tfidfw2v_dict['X_train_tfidfw2v
    tfidfw2v_lgr_train_score_list.append(tfidfw2v_lgr_train_score)
    tfidfw2v_lgr_val_score = tfidfw2v_lgr.score(tfidfw2v_dict['X_val_tfidfw2v'], 
    tfidfw2v_lgr_val_score_list.append(tfidfw2v_lgr_val_score)

c_all = [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
tfidfw2v_train_score = dict(zip(c_all, tfidfw2v_lgr_train_score_list))
tfidfw2v_val_score = dict(zip(c_all, tfidfw2v_lgr_val_score_list))
print(tfidfw2v_train_score)
print(tfidfw2v_val_score)
```

```
100%|██████████| 9/9 [18:45<00:00, 261.07s/it]

{0.0001: 0.89135, 0.001: 0.89135, 0.01: 0.89135, 0.1: 0.89135, 1: 0.89135, 10:
0.895, 100: 0.92135, 1000: 0.96455, 10000: 0.9948}
{0.0001: 0.8834, 0.001: 0.8834, 0.01: 0.8834, 0.1: 0.8834, 1: 0.8834, 10: 0.885
4, 100: 0.8882, 1000: 0.8632, 10000: 0.8466}
```

In [99]:
```
best_c = max(tfidfw2v_val_score, key=tfidfw2v_val_score.get)
best_c
```

Out[99]: 100

In [100]:
```
import pylab
plt.figure(figsize=(13, 10))
neighbors_settings = [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
plt.plot(neighbors_settings, tfidfw2v_lgr_train_score_list, label="training accur
plt.plot(neighbors_settings, tfidfw2v_lgr_val_score_list, label="validation accur
# plt.plot(neighbors_settings, auc_test, label="test accuracy", color='red')
plt.xlabel('C')
plt.ylabel('Accuracy')
plt.legend()
plt.xscale('log')

plt.show()
```



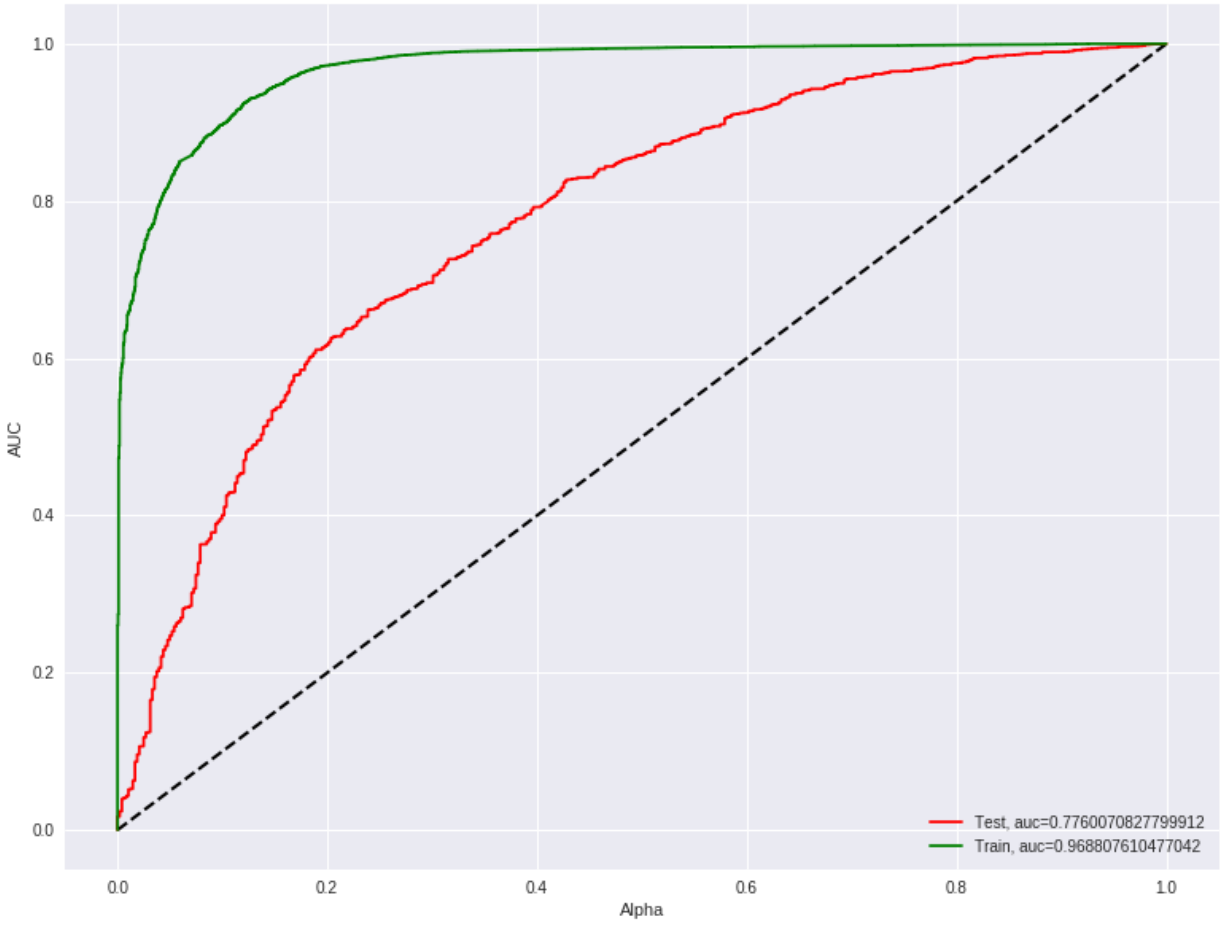
In [101]:
```
tfidfw2v_svm_linear=SVC(C=best_c, kernel='rbf')
tfidfw2v_svm_linear.fit(tfidfw2v_dict['X_train_tfidfw2v'], Y_train)
f = CalibratedClassifierCV(base_estimator=bow_svm_linear)
f.fit(tfidfw2v_dict['X_train_tfidfw2v'], Y_train)
tfidfw2v_test_proba = f.predict_proba(tfidfw2v_dict['X_test_tfidfw2v'])
tfidfw2v_train_proba = f.predict_proba(tfidfw2v_dict['X_train_tfidfw2v'])
tfidfw2v_test_proba
```

Out[101]:
```
array([[0.10412962, 0.89587038],
       [0.2323531 , 0.7676469 ],
       [0.05416867, 0.94583133],
       ...,
       [0.08060694, 0.91939306],
       [0.04606088, 0.95393912],
       [0.15819022, 0.84180978]])
```

In [102]:
```
tfidfw2v_fpr_train, tfidfw2v_tpr_train, _ = roc_curve(Y_train, tfidfw2v_train_pro
tfidfw2v_fpr_test, tfidfw2v_tpr_test, _ = roc_curve(Y_test, tfidfw2v_test_proba[:
tfidfw2v_test_auc = auc(tfidfw2v_fpr_test, tfidfw2v_tpr_test)
tfidfw2v_train_auc = auc(tfidfw2v_fpr_train, tfidfw2v_tpr_train)
print(tfidfw2v_test_auc)
print(tfidfw2v_train_auc)
```

```
0.7760070827799912
0.968807610477042
```

In [103]:
```
import pylab
plt.figure(figsize=(13, 10))
plt.plot([0,1], [0,1], color='black', lw=2, linestyle='--')
plt.plot(tfidfw2v_fpr_test, tfidfw2v_tpr_test, label="Test, auc="+str(tfidfw2v_te
plt.plot(tfidfw2v_fpr_train, tfidfw2v_tpr_train, label="Train, auc="+str(tfidfw2v_

plt.xlabel('Alpha')
plt.ylabel('AUC')
plt.legend()

plt.show()
```



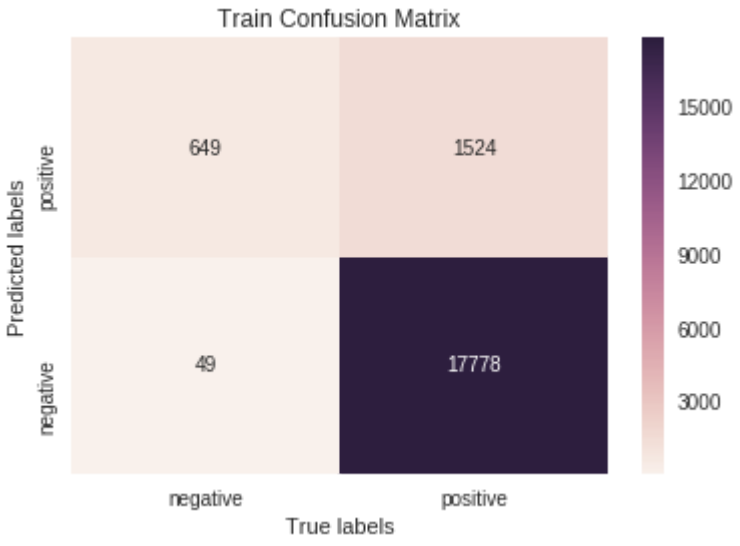
In [0]:
```
tfidfw2v_test_conf = tfidfw2v_svm_linear.predict(tfidfw2v_dict['X_test_tfidfw2v']
tfidfw2v_train_conf = tfidfw2v_svm_linear.predict(tfidfw2v_dict['X_train_tfidfw2v
```

In [105]:
```
from sklearn.metrics import classification_report, confusion_matrix
tfidfw2v_test_conf_matrix = confusion_matrix(Y_test, tfidfw2v_test_conf)
tfidfw2v_train_conf_matrix = confusion_matrix(Y_train, tfidfw2v_train_conf)
class_report = classification_report(Y_test, tfidfw2v_test_conf)
print(tfidfw2v_train_conf_matrix)
print(class_report)
```

```
[[  649  1524]
 [   49 17778]]
              precision    recall  f1-score   support

           0       0.59      0.14      0.22       482
           1       0.92      0.99      0.95      4518

   micro avg       0.91      0.91      0.91      5000
   macro avg       0.75      0.56      0.59      5000
weighted avg       0.88      0.91      0.88      5000
```

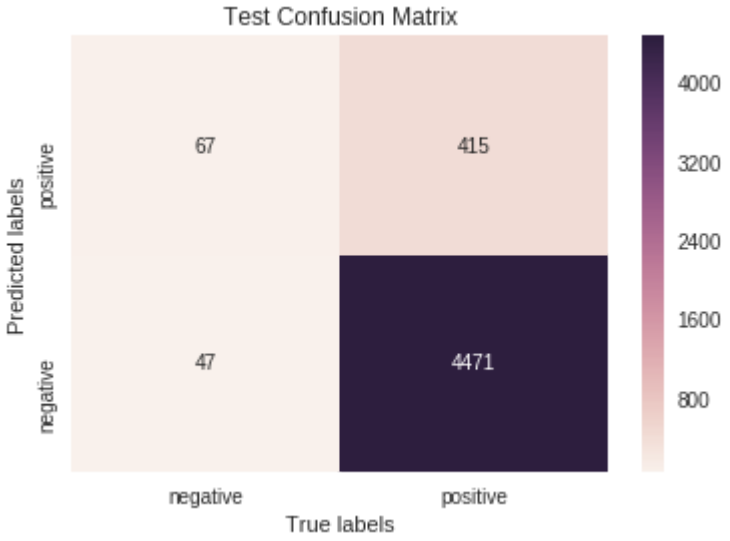
In [106]:
```
ax= plt.subplot()
sns.heatmap(tfidfw2v_train_conf_matrix, annot=True, ax = ax, fmt='g')

ax.set_ylabel('Predicted labels')
ax.set_xlabel('True labels')
ax.set_title('Train Confusion Matrix')
ax.xaxis.set_ticklabels(['negative', 'positive'])
ax.yaxis.set_ticklabels(['negative', 'positive'])
```

Out[106]: [Text(0, 0.5, 'negative'), Text(0, 1.5, 'positive')]



In [107]:
```
ax= plt.subplot()
sns.heatmap(tfidfw2v_test_conf_matrix, annot=True, ax = ax, fmt='g')

ax.set_ylabel('Predicted labels')
ax.set_xlabel('True labels')
ax.set_title('Test Confusion Matrix')
ax.xaxis.set_ticklabels(['negative', 'positive'])
ax.yaxis.set_ticklabels(['negative', 'positive'])
```

Out[107]: [Text(0, 0.5, 'negative'), Text(0, 1.5, 'positive')]



In [102]:
```
from prettytable import PrettyTable

x = PrettyTable()
x.field_names = ["Algorithm", "Vectorizer", "Train", "Test"]

x.add_row(["Linear SVM",  "BoW", 0.903, 0.904])
x.add_row(["Linear SVM", "Tf-idf", 0.764, 0.768])
x.add_row(["Linear SVM", "Avg-w2v", 0.921, 0.924])
x.add_row(["Linear SVM", "tfidf_w2v", 0.893, 0.895])
x.add_row(["RBF",  "BoW", 0.992, 0.954])
x.add_row(["RBF", "Tf-idf", 0.976, 0.903])
x.add_row(["RBF", "Avg-w2v", 0.936, 0.868])
x.add_row(["RBF", "tfidf_w2v", 0.968, 0.776])
print(x)
```

```
+------------+------------+-------+-------+
| Algorithm  | Vectorizer | Train |  Test |
+------------+------------+-------+-------+
| Linear SVM |    BoW     | 0.903 | 0.904 |
| Linear SVM |   Tf-idf   | 0.764 | 0.768 |
| Linear SVM |  Avg-w2v   | 0.921 | 0.924 |
| Linear SVM | tfidf_w2v  | 0.893 | 0.895 |
|    RBF     |    BoW     | 0.992 | 0.954 |
|    RBF     |   Tf-idf   | 0.976 | 0.903 |
|    RBF     |  Avg-w2v   | 0.936 | 0.868 |
|    RBF     | tfidf_w2v  | 0.968 | 0.776 |
+------------+------------+-------+-------+
```

Steps taken to increase accuracy:

i. Summary and Text columns are appended in single column

ii. length of words is taken from appended column and stacked with sparse matrix

Observations:

i. Accuracy increased around 2% for each vectorizer.