Assignment-9: Apply Random Forest On Amazon Fine Food Reviews DataSet ¶

Introduction

(i).A random forest consists of multiple random decision trees. Two types of randomnesses are built into the trees. First, each tree is built on a random sample from the original data. Second, at each tree node, a subset of features are randomly selected to generate the best split.

Objective

To Predict the Polarity of Amazon Fine Food Review Using Random Forest Algorithm.

Importing All Required Library

In [1]:

```
%matplotlib inline
import sqlite3
import pandas as pd
import numpy as np
import nltk
import string
import matplotlib.pyplot as plt
import seaborn as sns
import math

from sklearn.model_selection import GridSearchCV
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.ensemble import RandomForestClassifier
from sklearn.datasets import make_classification

from sklearn.metrics import classification_report
from sklearn.feature_extraction.text import TfidfTransformer
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.model_selection import TimeSeriesSplit

from sklearn.metrics import confusion_matrix
from sklearn import metrics
from sklearn.metrics import roc_curve, auc
from sklearn.model_selection import cross_val_score
from sklearn import preprocessing
from sklearn.metrics import accuracy_score
from sklearn.metrics import f1_score

from gensim.models import Word2Vec
from gensim.models import KeyedVectors


import pickle


from tqdm import tqdm
import os
import warnings
warnings.filterwarnings("ignore")
```

```
C:\Users\User\Anaconda3\lib\site-packages\gensim\utils.py:1197: UserWarning:
detected Windows; aliasing chunkize to chunkize_serial
  warnings.warn("detected Windows; aliasing chunkize to chunkize_serial")
```

Importing Amazon Fine Food Review Dataset

In [2]:

```
if os.path.isfile("final.sqlite"):
    conn=sqlite3.connect("final.sqlite")
    Data=pd.read_sql_query("select * from Reviews where Score!=3",conn)
    conn.close()
else :
    print("Error Importing the file")
```

In [3]:

```
# Printing some data of DataFrame

Data['Score'].value_counts()
```

Out[3]:

```
1    307061
0     57110
Name: Score, dtype: int64
```

Information About DataSet

In [4]:

```
print("\nNumber of Reviews: ",Data["Text"].count())
print("\nNumber of Users: ",len(Data["UserId"].unique())) # Unique returns 1-D
array of unique values of DataFrame.
print("\nNumber of Products: ",len(Data["ProductId"].unique()))
print("\nShape of Data: ", Data.shape)
print("\nColumn Name of DataSet : ",Data.columns)
print("\n\nNumber of Attributes/Columns in data: 12")
print("\nNumber of Positive Reviews : ", Data['Score'].value_counts()[1])
print("\nNumber of Negative Reviews : ", Data['Score'].value_counts()[0])
```

```
Number of Reviews:  364171

Number of Users:  243414

Number of Products:  65442

Shape of Data:  (364171, 12)

Column Name of DataSet :  Index(['index', 'Id', 'ProductId', 'UserId', 'Profi
leName',
       'HelpfulnessNumerator', 'HelpfulnessDenominator', 'Score', 'Time',
       'Summary', 'Text', 'CleanedText'],
      dtype='object')


Number of Attributes/Columns in data: 12

Number of Positive Reviews :  307061

Number of Negative Reviews :  57110
```

In [5]:

```
print("\nNumber of Reviews: ",Data["Text"].count())
```

```
Number of Reviews:  364171
```

Attribute Information About DataSet

1.Id - A unique value starts from 1

2.ProductId - A unique identifier for the product

3.UserId - A unqiue identifier for the user

4.ProfileName - Name of user profile

5.HelpfulnessNumerator - Number of users who found the review helpful

6.HelpfulnessDenominator - Number of users who indicated whether they found the review helpful or not

7.Score - Rating 0 or 1

8.Time - Timestamp for the review

9.Summary - Brief summary of the review

10.Text - Text of the review

11.Cleaned Text - Text that only alphabets

In [6]:
```
# Sorting on the basis of Time Parameter
Data.sort_values('Time',inplace=True)
```

In [7]:
```
Data=Data.head(100000)
```

In [8]:
```
Y = Data['Score']
X = Data['CleanedText']
```

Splitting DataSet into Train and Test Data

In [9]:
```
from sklearn.model_selection import train_test_split
# X_train, X_test, y_train, y_test = train_test_split(X, Y, test_size=0.33, shuffle=Flase): this is for time series split
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size=0.33,shuffle=False) # this is random splitting

print("Shape of Train and Test Dataset for 100k points")
print(X_train.shape, Y_train.shape)
print(X_test.shape, Y_test.shape)
```

```
Shape of Train and Test Dataset for 100k points
(67000,) (67000,)
(33000,) (33000,)
```

Defining Some Function

Train Data Confusion Matrix Plot

In [10]:

```python
def trainconfusionmatrix(model,X_train,y_train):
    print("Confusion Matrix for Train set")
    cm=confusion_matrix(y_train, model.predict(X_train))
    class_label = ["negative", "positive"]
    df_cm = pd.DataFrame(cm, index = class_label, columns = class_label)
    sns.heatmap(df_cm, annot = True, fmt = "d")
    plt.title("Train Confusiion Matrix")
    plt.xlabel("Predicted Label")
    plt.ylabel("True Label")
    plt.show()
```

Test Data Confusion Matrix Plot

In [11]:

```python
def testconfusionmatrix(model,X_test,y_test):
    print("Confusion Matrix for Test set")
    cm=confusion_matrix(y_test, model.predict(X_test))
    class_label = ["negative", "positive"]
    df_cm = pd.DataFrame(cm, index = class_label, columns = class_label)
    sns.heatmap(df_cm, annot = True, fmt = "d")
    plt.title("Test Confusiion Matrix")
    plt.xlabel("Predicted Label")
    plt.ylabel("True Label")
    plt.show()
```

ROC-AUC Curve

In [12]:

```python
def plot_auc_roc(model,X_train,X_test,y_train,y_test):
    train_fpr, train_tpr, thresholds = roc_curve(y_train,model.predict_proba(X
_train)[:,1])
    test_fpr, test_tpr, thresholds = roc_curve(y_test,model.predict_proba(X_te
st)[:,1])

    plt.plot(train_fpr, train_tpr, label="train AUC ="+str(auc(train_fpr, trai
n_tpr)))
    plt.plot(test_fpr, test_tpr, label="test AUC ="+str(auc(test_fpr, test_tpr
)))
    plt.legend()
    plt.xlabel("Hyperameter (C)")
    plt.ylabel("AUC")
    plt.title("ROC CURVE PLOTS")
    plt.show()
```

GridSearchCV

In [23]:
```
def Grid_SearchCV(X_train,Y_train):

    param_grid= {'max_depth':[1,5,10,50,100,500,1000],
                  'n_estimators' :[5,10,20,50,100]
                }
    tscv = TimeSeriesSplit(n_splits=10)
    clf = RandomForestClassifier(class_weight='balanced')
    gsv=GridSearchCV(clf,param_grid, scoring = 'roc_auc', cv=tscv,n_jobs=-1,pr
e_dispatch=2)
    gsv.fit(X_train,Y_train)

    return gsv
```

Train Auc Heatmap

In [26]:
```
def Train_Auc_Heatmap(gsv):
    results = gsv.cv_results_
    train = np.array(results['mean_train_score'])
    train = train.reshape(7,5)
    sns.heatmap(train,annot =True,yticklabels = [1,5,10,50,100,500,1000],xtick
labels =[5,10,20,50,100],linewidths=.5,cmap="YlGnBu" )
```

Test Auc Heatmap

In [27]:
```
def Cv_Auc_Heatmap(gsv):
    results = gsv.cv_results_
    cv = np.array(results['mean_test_score'])
    cv = cv.reshape(7,5)
    sns.heatmap(cv,annot =True,yticklabels = [1,5,10,50,100,500,1000],xticklab
els =[5,10,20,50,100],linewidths=.5 ,cmap= 'YlGnBu' )
```

Bags of Words Vectorizer

In [17]:
```
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_train_bow=preprocessing.normalize(X_train_bow)

X_test_bow = vectorizer.transform(X_test)
X_test_bow=preprocessing.normalize(X_test_bow)

print("Shape of Train and Test Data After vectorizations")
print(X_train_bow.shape, Y_train.shape)
print(X_test_bow.shape, Y_test.shape)
```

```
Shape of Train and Test Data After vectorizations
(67000, 30737) (67000,)
(33000, 30737) (33000,)
```

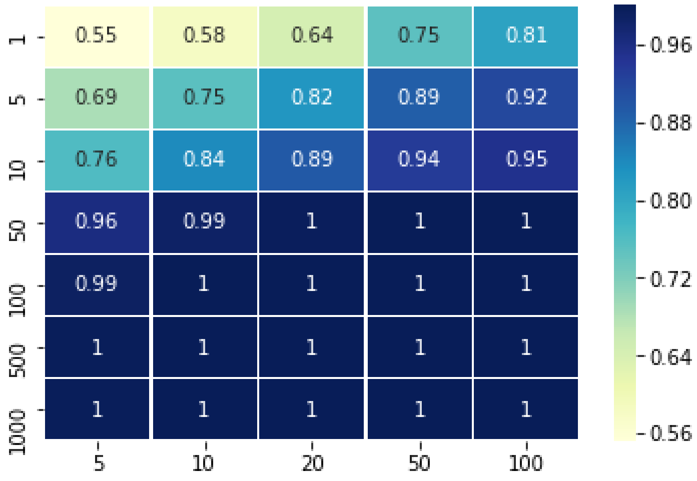
Finding the best value Of hyperparameter

In [24]:
```
gsv=Grid_SearchCV(X_train_bow,Y_train)

print("Best HyperParameter: ",gsv.best_params_)
print("Best Accuracy: %.2f%%"%(gsv.best_score_*100))
```

```
Best HyperParameter:  {'max_depth': 500, 'n_estimators': 100}
Best Accuracy: 90.96%
```

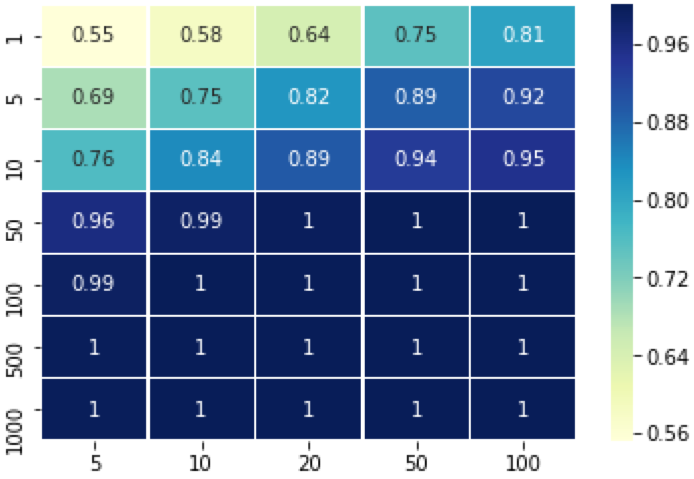
Train Auc HeatMap

In [28]:
```
Train_Auc_Heatmap(gsv)
```



Test Auc Heatmap

In [29]:
```
Train_Auc_Heatmap(gsv)
```



Training the model

In [30]:
```
Best_Param=gsv.best_params_
depth=Best_Param['max_depth']
n_estimator =Best_Param['n_estimators']

Model_Bow=RandomForestClassifier(max_depth=depth,n_estimators=n_estimator,clas
s_weight="balanced")
Model_Bow.fit(X_train_bow,Y_train)
```

Out[30]:
```
RandomForestClassifier(bootstrap=True, class_weight='balanced',
            criterion='gini', max_depth=500, max_features='auto',
            max_leaf_nodes=None, min_impurity_decrease=0.0,
            min_impurity_split=None, min_samples_leaf=1,
            min_samples_split=2, min_weight_fraction_leaf=0.0,
            n_estimators=100, n_jobs=None, oob_score=False,
            random_state=None, verbose=0, warm_start=False)
```

In [44]:
```
from sklearn.externals import joblib
joblib.dump(Model_Bow,"BOW_Model.pkl")
```

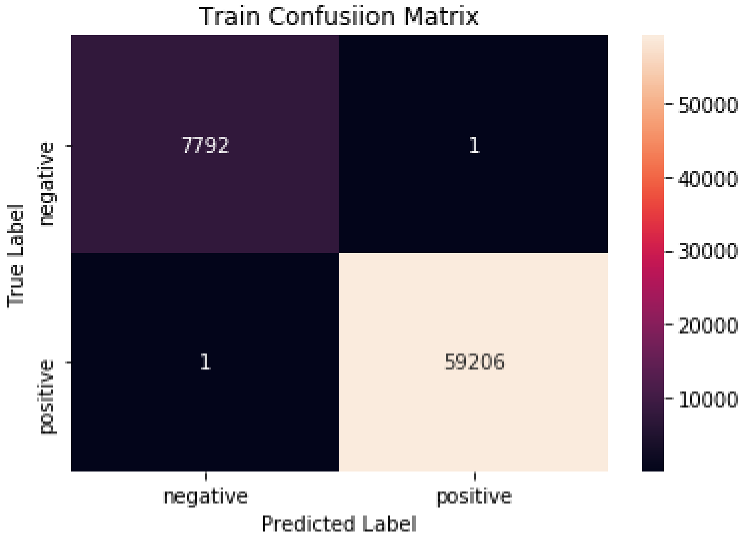
Out[44]:
```
['BOW_Model.pkl']
```

In [18]:
```
from sklearn.externals import joblib
Model_Bow=joblib.load("BOW_Model.pkl")
```

Evaluating the performance of model

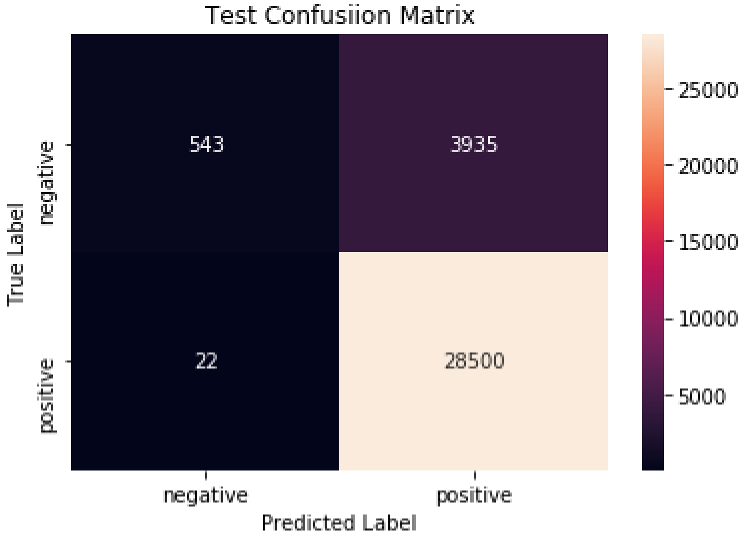
In [31]:
```
trainconfusionmatrix(Model_Bow,X_train_bow,Y_train)
```

```
Confusion Matrix for Train set
```

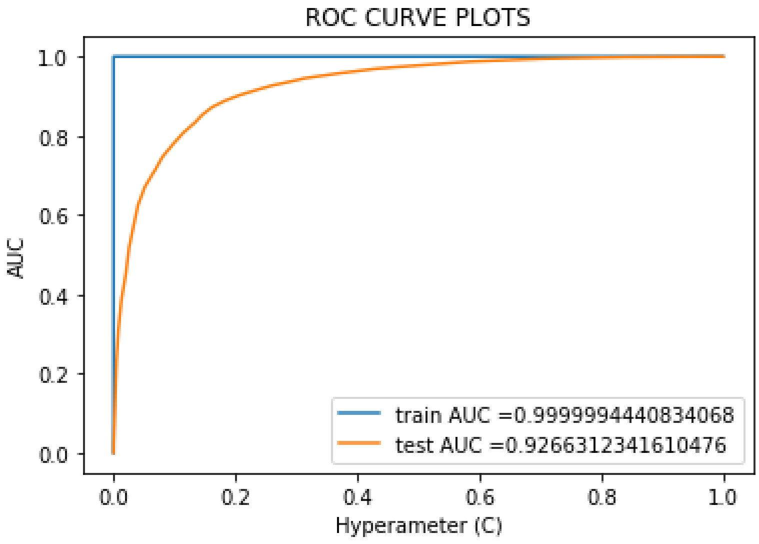


In [32]:
```
testconfusionmatrix(Model_Bow,X_test_bow,Y_test)
```

```
Confusion Matrix for Test set
```



In [34]:
```
plot_auc_roc(Model_Bow,X_train_bow,X_test_bow,Y_train,Y_test)
```

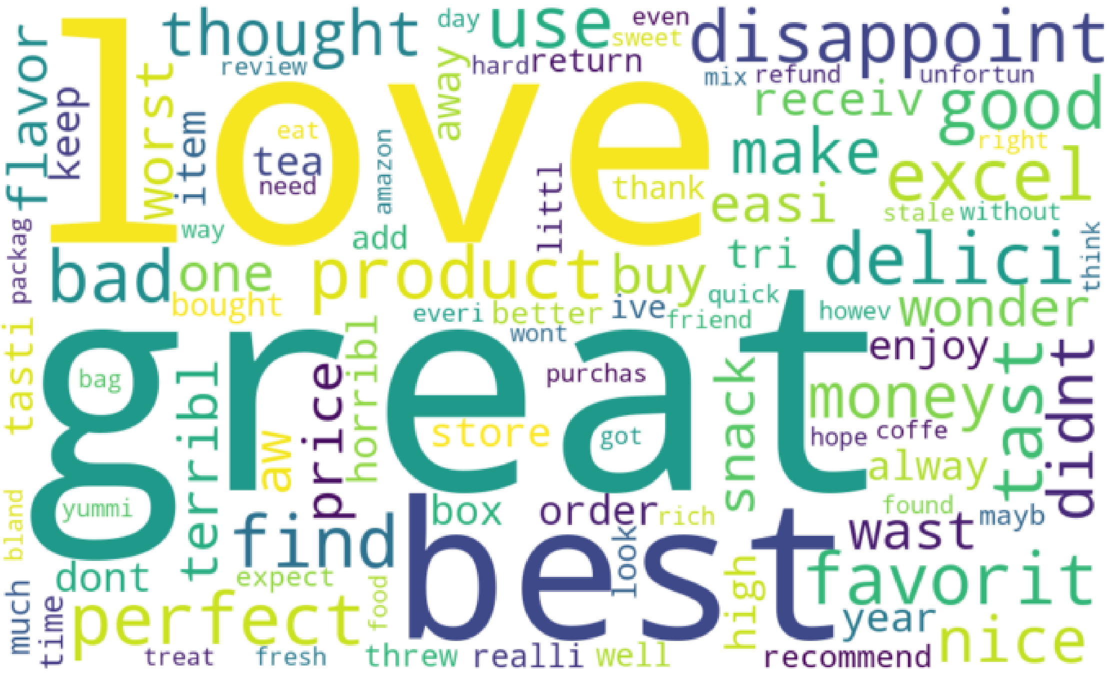


In [35]:
```
print("Classification Report: \n")
y_pred=Model_Bow.predict(X_test_bow)

print(classification_report(Y_test, y_pred))
```

```
Classification Report: 

              precision    recall  f1-score   support

           0       0.96      0.12      0.22      4478
           1       0.88      1.00      0.94     28522

   micro avg       0.88      0.88      0.88     33000
   macro avg       0.92      0.56      0.58     33000
weighted avg       0.89      0.88      0.84     33000
```

Important Feature

```
In [39]: from wordcloud import WordCloud, STOPWORDS

         features =vectorizer.get_feature_names()
         coef = Model_Bow.feature_importances_
         coef_df = pd.DataFrame({'word': features, 'coeficient': coef}, index = None)
         df = coef_df.sort_values("coeficient", ascending = False)[:100]
         cloud = " ".join(word for word in df.word)
         stopwords = set(STOPWORDS)
         wordcloud = WordCloud(width = 1000, height = 600, background_color ='white', s
         topwords = stopwords).generate(cloud)

         # plot the WordCloud image
         plt.figure(figsize = (10, 8))
         plt.imshow(wordcloud, interpolation = 'bilinear')
         plt.axis("off")
         #plt.title("Top 100 most important features\n")
         plt.tight_layout(pad = 0)

         plt.show()
```



TF-IDF Vectorizer

In [40]:

```
vectorizer_tfidf=TfidfVectorizer()
vectorizer_tfidf.fit(X_train)
```

Out[40]:

```
TfidfVectorizer(analyzer='word', binary=False, decode_error='strict',
        dtype=<class 'numpy.float64'>, encoding='utf-8', input='content',
        lowercase=True, max_df=1.0, max_features=None, min_df=1,
        ngram_range=(1, 1), norm='l2', preprocessor=None, smooth_idf=True,
        stop_words=None, strip_accents=None, sublinear_tf=False,
        token_pattern='(?u)\\b\\w\\w+\\b', tokenizer=None, use_idf=True,
        vocabulary=None)
```

In [41]:

```
X_Train_Tfidf=vectorizer_tfidf.transform(X_train)
X_Train_Tfidf=preprocessing.normalize(X_Train_Tfidf)

X_Test_Tfidf=vectorizer_tfidf.transform(X_test)
X_Test_Tfidf=preprocessing.normalize(X_Test_Tfidf)
```

In [42]:

```
print("Shape of Train and Test Data After vectorizations")
print(X_Train_Tfidf.shape, Y_train.shape)
print(X_Test_Tfidf.shape, Y_test.shape)
```

```
Shape of Train and Test Data After vectorizations
(67000, 30737) (67000,)
(33000, 30737) (33000,)
```

Finding the best value Of hyperparameter

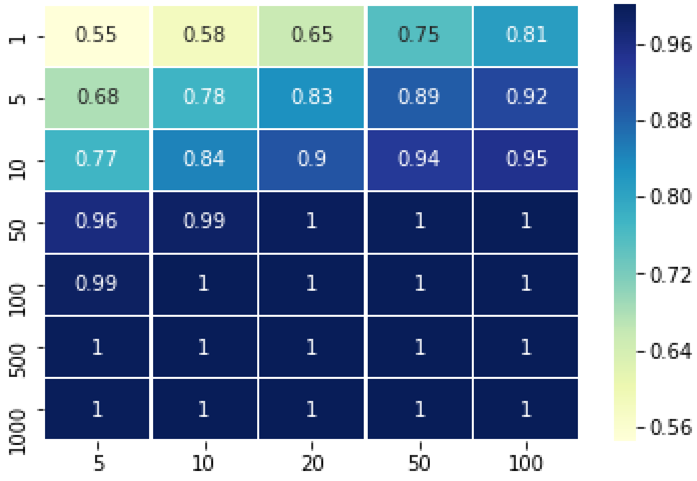
In [43]:

```
gsv=Grid_SearchCV(X_Train_Tfidf,Y_train)

print("Best HyperParameter: ",gsv.best_params_)
print("Best Accuracy: %.2f%%"%(gsv.best_score_*100))
```

```
Best HyperParameter:  {'max_depth': 1000, 'n_estimators': 100}
Best Accuracy: 90.99%
```

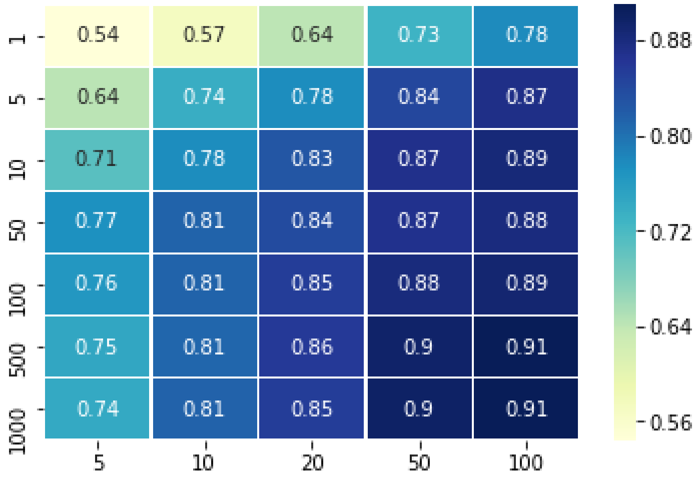
Train Auc HeatMap

In [44]:
```
Train_Auc_Heatmap(gsv)
```



Test Auc Heatmap

In [45]:
```
Cv_Auc_Heatmap(gsv)
```



Training the model

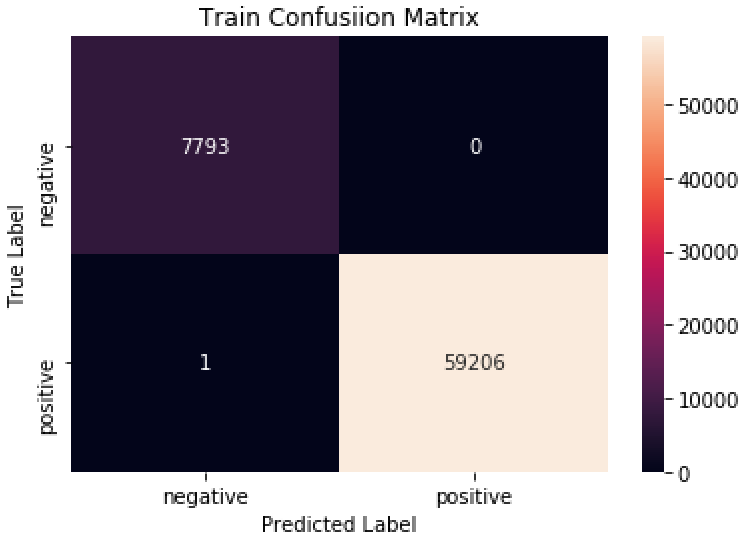
In [47]:
```
Best_Param=gsv.best_params_
depth=Best_Param['max_depth']
n_estimator =Best_Param['n_estimators']

Model_Tfidf=RandomForestClassifier(max_depth=depth,n_estimators=n_estimator,cl
ass_weight="balanced")
Model_Tfidf.fit(X_Train_Tfidf,Y_train)
```

Out[47]:
```
RandomForestClassifier(bootstrap=True, class_weight='balanced',
            criterion='gini', max_depth=1000, max_features='auto',
            max_leaf_nodes=None, min_impurity_decrease=0.0,
            min_impurity_split=None, min_samples_leaf=1,
            min_samples_split=2, min_weight_fraction_leaf=0.0,
            n_estimators=100, n_jobs=None, oob_score=False,
            random_state=None, verbose=0, warm_start=False)
```

Evaluating the performance of model

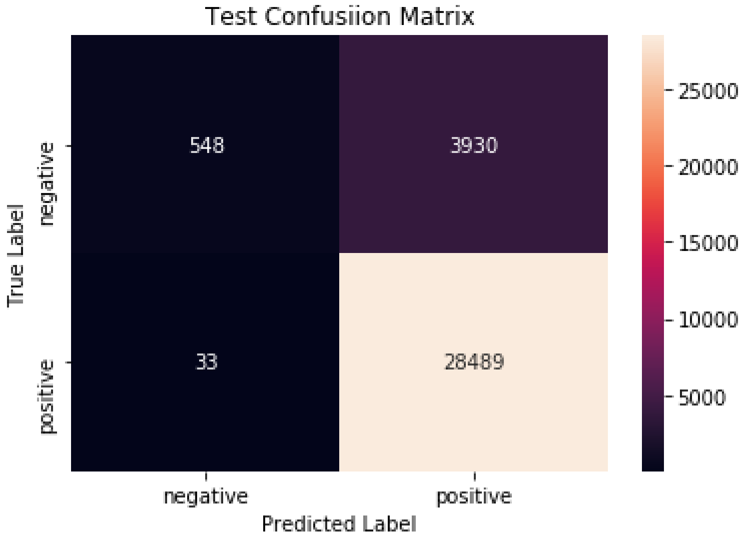
In [48]:
```
trainconfusionmatrix(Model_Tfidf,X_Train_Tfidf,Y_train)
```

```
Confusion Matrix for Train set
```

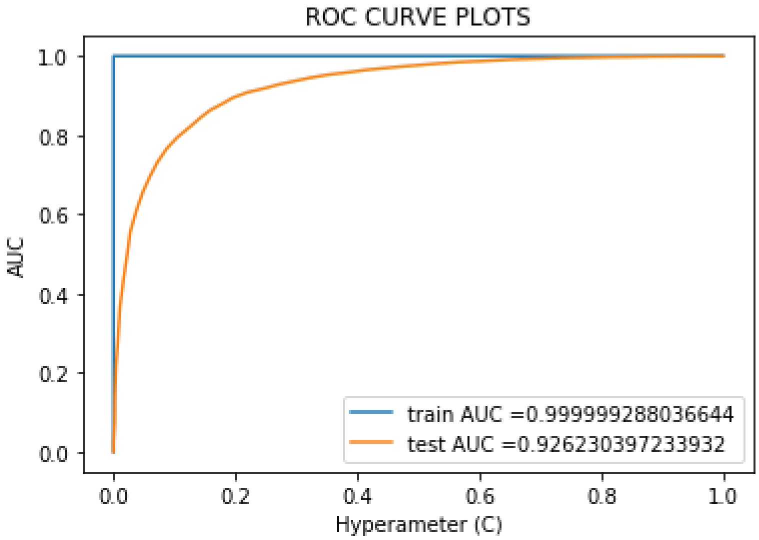


In [49]:
```
testconfusionmatrix(Model_Tfidf,X_Test_Tfidf,Y_test)
```

```
Confusion Matrix for Test set
```



In [50]:
```
plot_auc_roc(Model_Tfidf,X_Train_Tfidf,X_Test_Tfidf,Y_train,Y_test)
```

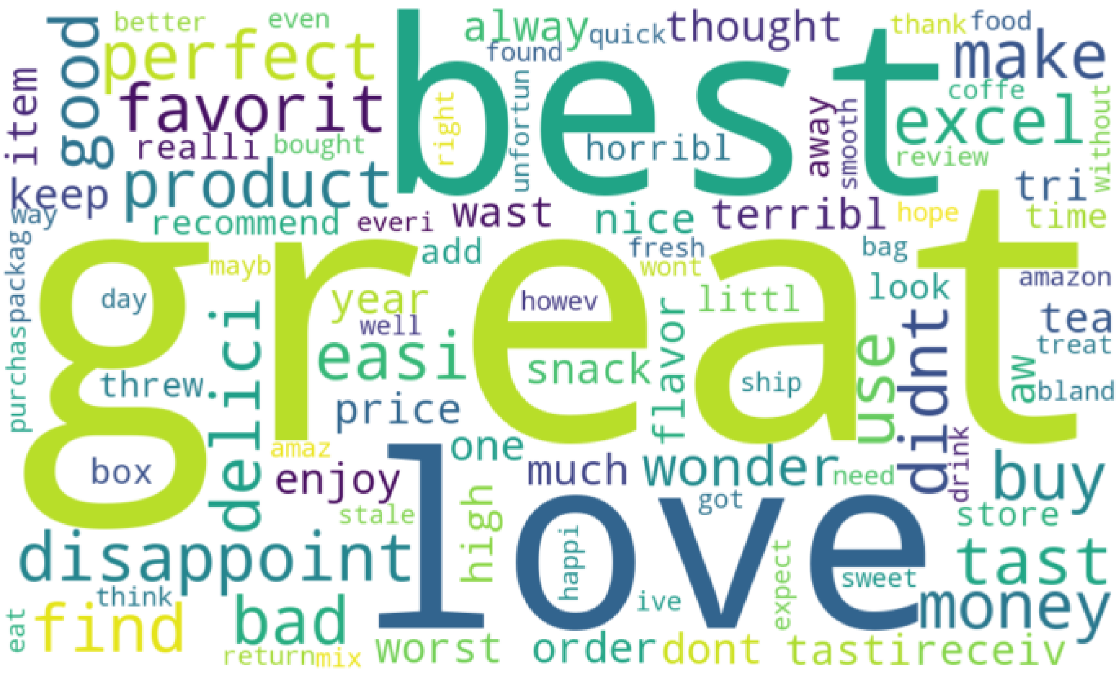


In [51]:
```
print("Classification Report: \n")
y_pred=Model_Tfidf.predict(X_Test_Tfidf)

print(classification_report(Y_test, y_pred))
```

```
Classification Report: 

              precision    recall  f1-score   support

           0       0.94      0.12      0.22      4478
           1       0.88      1.00      0.93     28522

   micro avg       0.88      0.88      0.88     33000
   macro avg       0.91      0.56      0.58     33000
weighted avg       0.89      0.88      0.84     33000
```

Important Features

In [53]:
```
from wordcloud import WordCloud, STOPWORDS

features =vectorizer.get_feature_names()
coef = Model_Tfidf.feature_importances_
coef_df = pd.DataFrame({'word': features, 'coeficient': coef}, index = None)
df = coef_df.sort_values("coeficient", ascending = False)[:100]
cloud = " ".join(word for word in df.word)
stopwords = set(STOPWORDS)
wordcloud = WordCloud(width = 1000, height = 600, background_color ='white', s
topwords = stopwords).generate(cloud)

# plot the WordCloud image
plt.figure(figsize = (10, 8))
plt.imshow(wordcloud, interpolation = 'bilinear')
plt.axis("off")
#plt.title("Top 100 most important features\n")
plt.tight_layout(pad = 0)

plt.show()
```



Word To Vector

In [54]:
```
list_of_Train_sent=[]
list_of_Test_sent=[]

for sent in X_train:
    list_of_Train_sent.append(sent.split())

for sent in X_test:
    list_of_Test_sent.append(sent.split())
```

In [55]:
```
model=Word2Vec(list_of_Train_sent,min_count=5,size=50, workers=4)
```

Average Word To Vector

In [56]:
```
import numpy as np

Train_vectors = []
for sent in list_of_Train_sent:
    sent_vec = np.zeros(50)
    cnt_words = 0
    for word in sent:
        try:
            vec = model.wv[word]
            sent_vec += vec
            cnt_words += 1
        except:
            pass
    if cnt_words!=0:
        sent_vec /= cnt_words
    Train_vectors.append(sent_vec)
Train_vectors = np.nan_to_num(Train_vectors)
```

In [57]:
```
import numpy as np

Test_vectors=[]
for sent in list_of_Test_sent:
    sent_vec=np.zeros(50)
    cnt_words=0
    for word in sent:
        try:
            vec=model.wv[word]
            sent_vec+=vec
            cnt_words+=1
        except:
            pass
    if cnt_words!=0:
        sent_vec/=cnt_words
    Test_vectors.append(sent_vec)
Test_vectors=np.nan_to_num(Test_vectors)
```

In [58]:
```
print("Shape of Test Vectors : ",Test_vectors.shape)
```

```
Shape of Test Vectors :  (33000, 50)
```

In [59]:
```
X_Train_Awv=Train_vectors
X_Test_Awv=Test_vectors
```

In [60]:
```
print(X_Train_Awv.shape, Y_train.shape)
print(X_Test_Awv.shape, Y_test.shape)
```

```
(67000, 50) (67000,)
(33000, 50) (33000,)
```

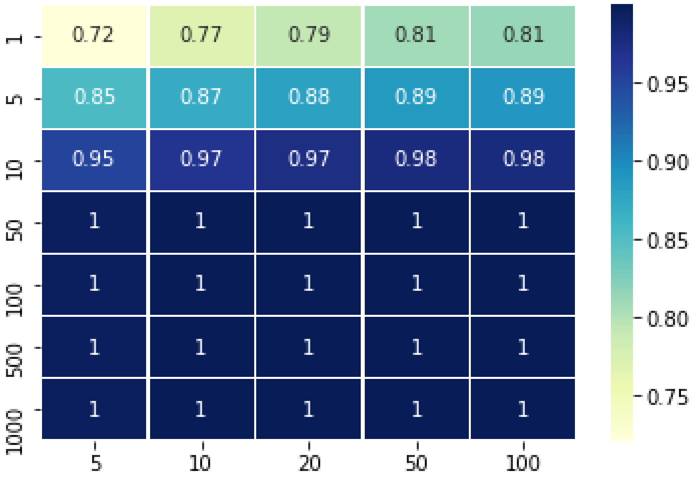
Finding the best value Of hyperparameter

In [61]:
```
gsv=Grid_SearchCV(X_Train_Awv,Y_train)

print("Best HyperParameter: ",gsv.best_params_)
print("Best Accuracy: %.2f%%"%(gsv.best_score_*100))
```

```
Best HyperParameter:  {'max_depth': 50, 'n_estimators': 100}
Best Accuracy: 87.15%
```

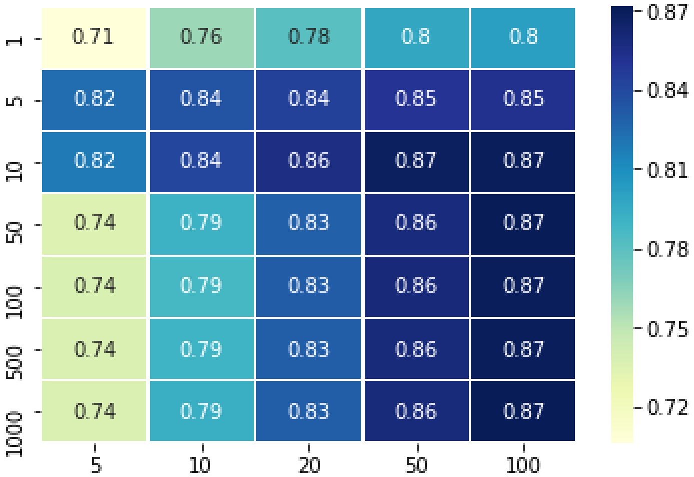
Train Auc Heatmap

In [62]:
```
Train_Auc_Heatmap(gsv)
```



Test Auc Heatmap

In [63]:
```
Cv_Auc_Heatmap(gsv)
```



Training Model

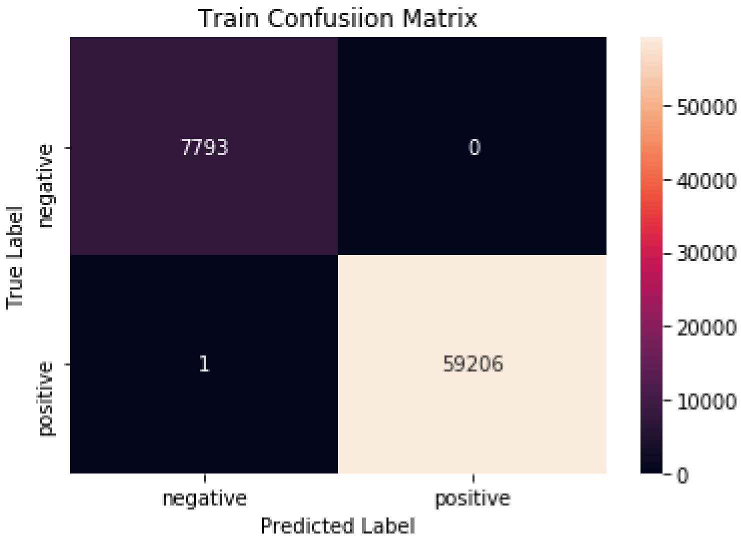
In [64]:
```
Best_Param=gsv.best_params_
depth=Best_Param['max_depth']
n_estimator =Best_Param['n_estimators']

Model_Awv=RandomForestClassifier(max_depth=depth,n_estimators=n_estimator,clas
s_weight="balanced")
Model_Awv.fit(X_Train_Awv,Y_train)
```

Out[64]:
```
RandomForestClassifier(bootstrap=True, class_weight='balanced',
            criterion='gini', max_depth=50, max_features='auto',
            max_leaf_nodes=None, min_impurity_decrease=0.0,
            min_impurity_split=None, min_samples_leaf=1,
            min_samples_split=2, min_weight_fraction_leaf=0.0,
            n_estimators=100, n_jobs=None, oob_score=False,
            random_state=None, verbose=0, warm_start=False)
```

Evaluating the performance of model

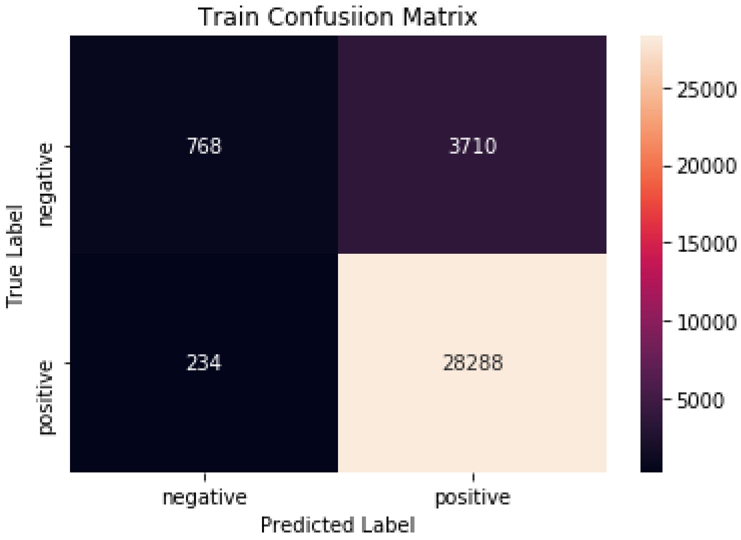
```
In [65]: trainconfusionmatrix(Model_Awv,X_Train_Awv,Y_train)
```

```
Confusion Matrix for Train set
```



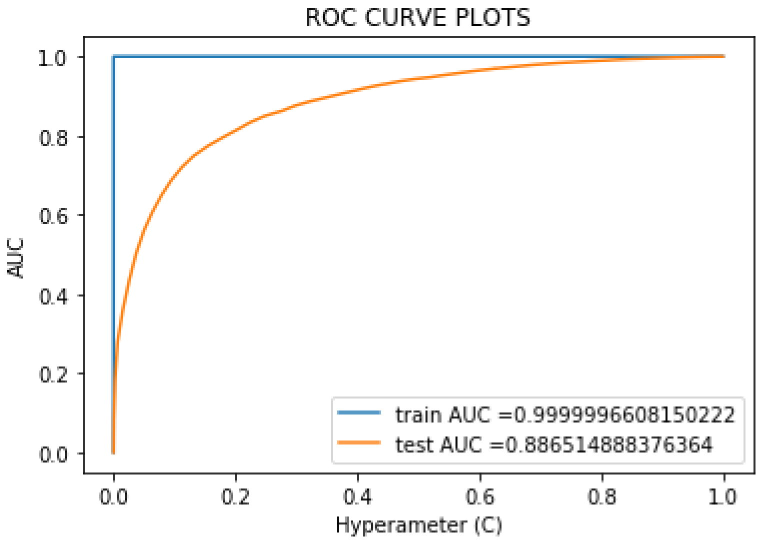
```
In [66]: trainconfusionmatrix(Model_Awv,X_Test_Awv,Y_test)
```

```
Confusion Matrix for Train set
```



In [69]:

```
plot_auc_roc(Model_Awv,X_Train_Awv,X_Test_Awv,Y_train,Y_test)
```



In [68]:

```
print("Classification Report: \n")
y_pred=Model_Awv.predict(X_Test_Awv)

print(classification_report(Y_test, y_pred))
```

```
Classification Report: 

              precision    recall  f1-score   support

           0       0.77      0.17      0.28      4478
           1       0.88      0.99      0.93     28522

   micro avg       0.88      0.88      0.88     33000
   macro avg       0.83      0.58      0.61     33000
weighted avg       0.87      0.88      0.85     33000
```

TF-IDF Word To Vector

In [70]:

```
TFIDF_Feature=vectorizer_tfidf.get_feature_names()
print(len(TFIDF_Feature))
print(TFIDF_Feature[0:20])
```

```
30737
['aaa', 'aaaaaaaaagghh', 'aaaaah', 'aaaaahhhhhhhhhhhhhhhh', 'aaaah', 'aaah',
'aachen', 'aad', 'aadp', 'aafco', 'aagh', 'aah', 'aahh', 'aand', 'aardvark',
'ab', 'aback', 'abandon', 'abaolut', 'abattoir']
```

In [71]:

```
w2v_words = list(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  10488
Sample words  ['witti', 'littl', 'book', 'make', 'son', 'laugh', 'loud', 'ca
r', 'drive', 'along', 'alway', 'sing', 'refrain', 'hes', 'learn', 'whale', 'i
ndia', 'droop', 'love', 'new', 'word', 'introduc', 'silli', 'classic', 'wil
l', 'bet', 'still', 'abl', 'memori', 'colleg', 'rememb', 'see', 'show', 'ai
r', 'televis', 'year', 'ago', 'child', 'sister', 'later', 'bought', 'day', 't
hirti', 'someth', 'use', 'seri', 'song', 'student', 'teach', 'preschool']
```

In [72]:

```
from tqdm import tqdm
Train_TFIDF_W2V_Vectors=[]
row=0
for sent in tqdm(list_of_Train_sent):
    sent_vec=np.zeros(50)
    weight=0
    for word in sent:
        try :
            if word in TFIDF_Feature and word in w2v_words:

                w2v_vec=model.wv[word]
                tfidf_vec=X_Train_Tfidf[row,TFIDF_Feature.index(word)]
                sent_vec+=(w2v_vec*tfidf_vec)
                weight+=tfidf_vec

        except :
            pass
    if weight!=0:
        sent_vec/=weight
    Train_TFIDF_W2V_Vectors.append(sent_vec)
    row+=1
```

```
100%|██████████| 67000/67000 [1:00:12<00:00, 18.55it/
s]
```

In [73]:

```
Test_TFIDF_W2V_Vectors=[]
row=0
for sent in tqdm(list_of_Test_sent):
    sent_vec=np.zeros(50)
    weight=0

    for word in sent:
        try:
             if word in TFIDF_Feature and word in w2v_words:

                w2v_vec=model.wv[word]
                tfidf_vec=X_Test_Tfidf(row,TFIDF_Feature.index(word))
                sent_vec+=(w2v_vec*tfidf_vec)
                weight+=tfidf

        except :
            pass

    if weight!=0:
        sent_vec/=weight
    Test_TFIDF_W2V_Vectors.append(sent_vec)
    row+=1
```

```
100%|████████████████████████████████████| 33000/33000 [23:28<00:00, 23.42it/
s]
```

In [74]:

```
Train_TFIDF_W2V_Vectors = np.nan_to_num(Train_TFIDF_W2V_Vectors)
Test_TFIDF_W2V_Vectors = np.nan_to_num(Test_TFIDF_W2V_Vectors)
```

In [75]:

```
X_Train_TfidfW2v=Train_TFIDF_W2V_Vectors
X_Test_TfidfW2v=Test_TFIDF_W2V_Vectors
```

In [76]:

```
print(X_Train_TfidfW2v.shape, Y_train.shape)
print(X_Test_TfidfW2v.shape, Y_test.shape)
```

```
(67000, 50) (67000,)
(33000, 50) (33000,)
```

Finding the best value Of hyperparameter

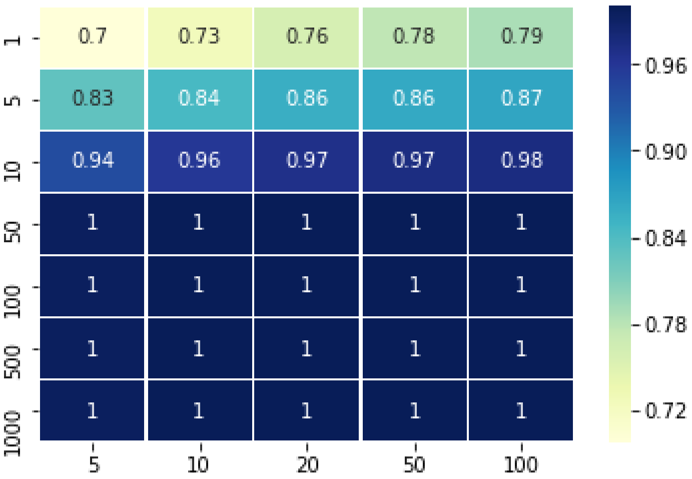
In [77]:

```
gsv=Grid_SearchCV(X_Train_TfidfW2v,Y_train)

print("Best HyperParameter: ",gsv.best_params_)
print("Best Accuracy: %.2f%%"%(gsv.best_score_*100))
```

```
Best HyperParameter:  {'max_depth': 500, 'n_estimators': 100}
Best Accuracy: 84.17%
```

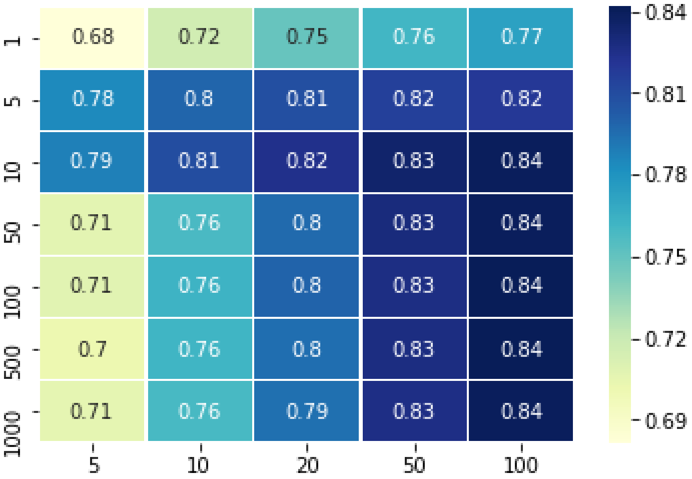
Train Auc Heatmap

In [78]:
```
Train_Auc_Heatmap(gsv)
```



Test Auc Heatmap

In [79]:
```
Cv_Auc_Heatmap(gsv)
```



Training Model

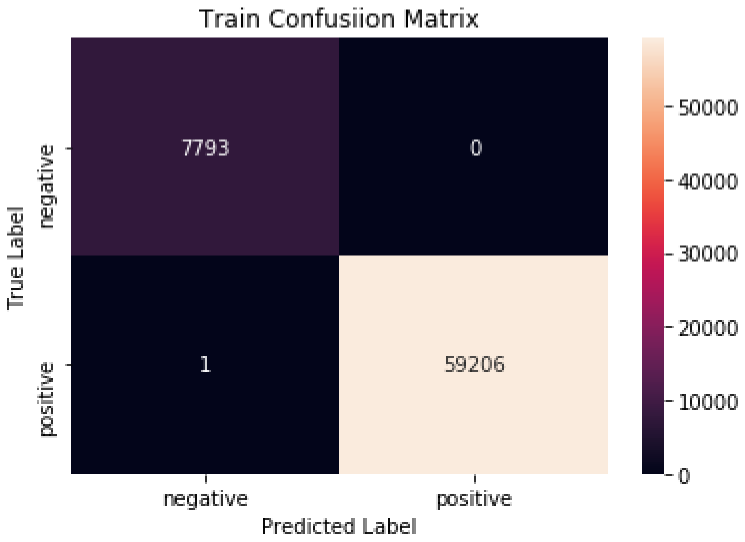
```
In [80]: Best_Param=gsv.best_params_
         n_estimator =Best_Param['n_estimators']

         Model_TfidfW2v=RandomForestClassifier(max_depth=depth,n_estimators=n_estimator
         ,class_weight="balanced")
         Model_TfidfW2v.fit(X_Train_TfidfW2v,Y_train)
```

```
Out[80]: RandomForestClassifier(bootstrap=True, class_weight='balanced',
                      criterion='gini', max_depth=50, max_features='auto',
                      max_leaf_nodes=None, min_impurity_decrease=0.0,
                      min_impurity_split=None, min_samples_leaf=1,
                      min_samples_split=2, min_weight_fraction_leaf=0.0,
                      n_estimators=100, n_jobs=None, oob_score=False,
                      random_state=None, verbose=0, warm_start=False)
```

Evaluating the performance of model

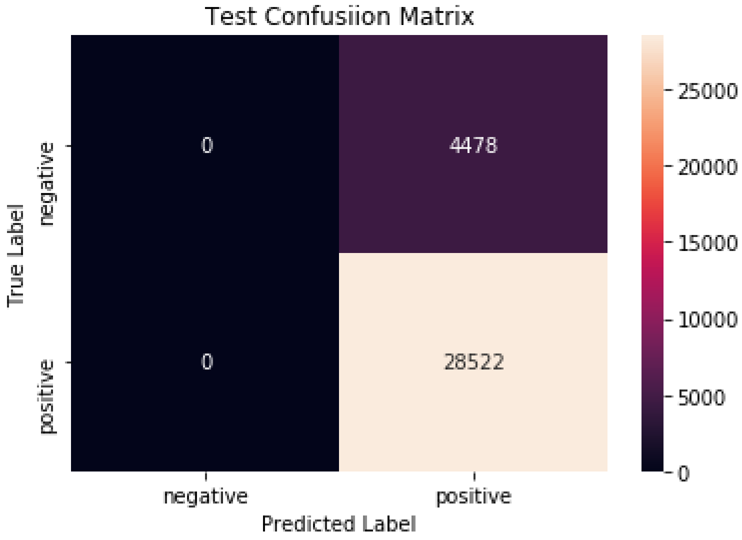
```
In [81]: trainconfusionmatrix(Model_TfidfW2v,X_Train_TfidfW2v,Y_train)
```

```
Confusion Matrix for Train set
```

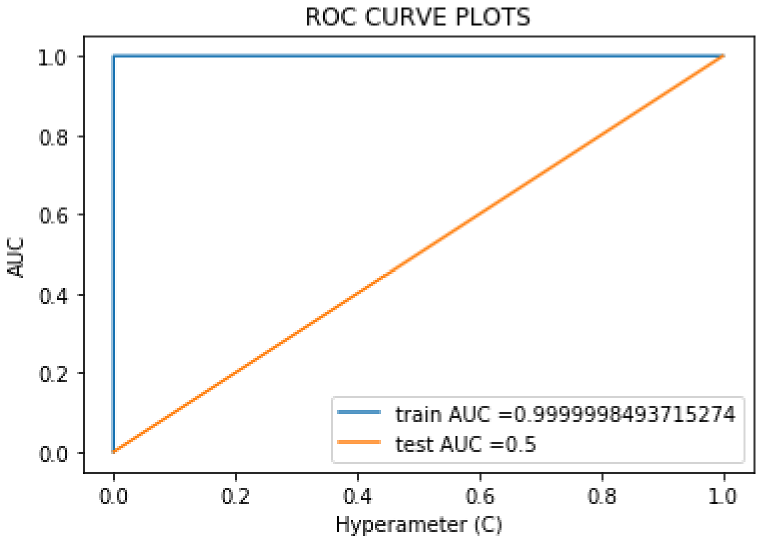


```
In [82]: testconfusionmatrix(Model_TfidfW2v,X_Test_TfidfW2v,Y_test)
```

```
Confusion Matrix for Test set
```



```
In [83]: plot_auc_roc(Model_TfidfW2v,X_Train_TfidfW2v,X_Test_TfidfW2v,Y_train,Y_test)
```



In [84]:
```
print("Classification Report: \n")
y_pred=Model_TfidfW2v.predict(X_Test_TfidfW2v)

print(classification_report(Y_test, y_pred))
```

```
Classification Report: 

              precision    recall  f1-score   support

           0       0.00      0.00      0.00      4478
           1       0.86      1.00      0.93     28522

   micro avg       0.86      0.86      0.86     33000
   macro avg       0.43      0.50      0.46     33000
weighted avg       0.75      0.86      0.80     33000
```

Conclusion

1. Report on different vectorizer method

In [2]:
```
from prettytable import PrettyTable

x = PrettyTable()

x.field_names = ["Vectorizer", "Hyperparameter(max_depth)","Hyperparameter(n_e
stimator)","Train AUC","Test AUC","F1-Score"]

x.add_row(["BOW",500,100,0.99,0.92,0.84])
x.add_row(["TF-IDF",1000,100,0.99,0.92,0.84])
x.add_row(["Avg W2V",50,100,0.99,0.88,0.85])
x.add_row(["TF-IDF W2V",500,100,0.99,0.50,0.80])

print(x)
```

```
+------------+---------------------------+-----------------------------+-----
------+----------+----------+
| Vectorizer | Hyperparameter(max_depth) | Hyperparameter(n_estimator) | Trai
n AUC | Test AUC | F1-Score |
+------------+---------------------------+-----------------------------+-----
------+----------+----------+
|    BOW     |            500            |             100             |     
0.99    |   0.92   |   0.84   |
|   TF-IDF   |            1000           |             100             |     
0.99    |   0.92   |   0.84   |
|  Avg W2V   |             50            |             100             |     
0.99    |   0.88   |   0.85   |
| TF-IDF W2V |            500            |             100             |     
0.99    |   0.5    |   0.8    |
+------------+---------------------------+-----------------------------+-----
------+----------+----------+
```

1. I have taken two hyper-parameter to train model that is max_depth and n_estimator.
2. In BOW and TF-IDF , model is performing well .
3. Model is Overfit in case of TF-IDF W2v .