In [6]:

```
import pandas as pd
import matplotlib.pyplot as plt
import re
import time
import warnings
import sqlite3
from sqlalchemy import create_engine # database connection
import csv
import os
warnings.filterwarnings("ignore")
import datetime as dt
import numpy as np
from nltk.corpus import stopwords
from sklearn.decomposition import TruncatedSVD
from sklearn.preprocessing import normalize
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.manifold import TSNE
import seaborn as sns
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import confusion_matrix
from sklearn.metrics.classification import accuracy_score, log_loss
from sklearn.feature_extraction.text import TfidfVectorizer
from collections import Counter
from scipy.sparse import hstack
from sklearn.multiclass import OneVsRestClassifier
from sklearn.svm import SVC
from collections import Counter, defaultdict
from sklearn.calibration import CalibratedClassifierCV
from sklearn.naive_bayes import MultinomialNB
from sklearn.naive_bayes import GaussianNB
from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV
import math
from sklearn.metrics import normalized_mutual_info_score
from sklearn.ensemble import RandomForestClassifier

from sklearn.model_selection import cross_val_score
from sklearn.linear_model import SGDClassifier
from mlxtend.classifier import StackingClassifier

from sklearn import model_selection
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import precision_recall_curve, auc, roc_curve
from scipy import sparse
import pickle
```

4. Machine Learning Models

4.3 Random train test split(70:30)

In [7]:

```
# function to load the pickle data
def loadPickleData(filename):
    pickle_off = open(filename,"rb")
    final = pickle.load(pickle_off)
    return final
```

In [15]:

```
y_train = loadPickleData('y_train.pickle')
y_test = loadPickleData('y_test.pickle')
y_cv = loadPickleData('y_cv.pickle')
X_train = loadPickleData('train_f.pickle')
X_test = loadPickleData('test_f.pickle')
X_cv = loadPickleData('cv_f.pickle')
```

In [18]:

```
print("-"*10, "Distribution of output variable in train data", "-"*10)
train_distr = Counter(y_train)
train_len = len(y_train)
print("Class 0: ",int(train_distr[0])/train_len,"Class 1: ", int(train_distr[1])
/train_len)
print("-"*10, "Distribution of output variable in train data", "-"*10)
test_distr = Counter(y_test)
test_len = len(y_test)
print("Class 0: ",int(test_distr[1])/test_len, "Class 1: ",int(test_distr[1])/te
st_len)
```

```
---------- Distribution of output variable in train data ----------
Class 0:  0.62746875 Class 1:  0.37253125
---------- Distribution of output variable in train data ----------
Class 0:  0.37255 Class 1:  0.37255
```

In [19]:

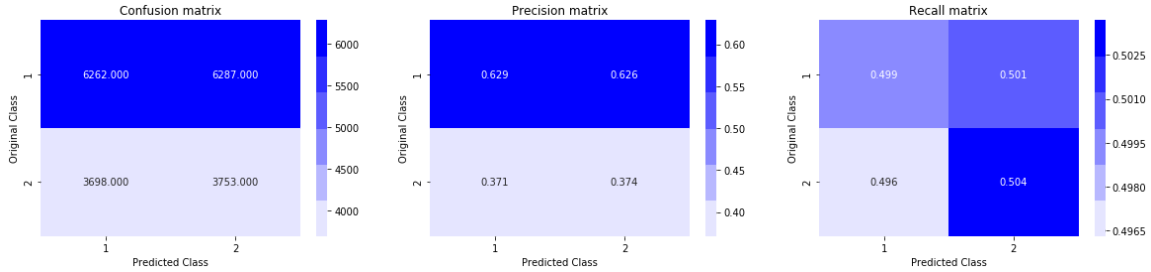
```
# This function plots the confusion matrices given y_i, y_i_hat.
def plot_confusion_matrix(test_y, predict_y):
    C = confusion_matrix(test_y, predict_y)
    A =(((C.T)/(C.sum(axis=1))).T)
    B =(C/C.sum(axis=0))
    plt.figure(figsize=(20,4))

    labels = [1,2]
    # representing A in heatmap format
    cmap=sns.light_palette("blue")
    plt.subplot(1, 3, 1)
    sns.heatmap(C, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels, yticklabels=labels)
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.title("Confusion matrix")

    plt.subplot(1, 3, 2)
    sns.heatmap(B, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels, yticklabels=labels)
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.title("Precision matrix")

    plt.subplot(1, 3, 3)
    # representing B in heatmap format
    sns.heatmap(A, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels, yticklabels=labels)
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.title("Recall matrix")

    plt.show()
```

4.4 Building a random model (Finding worst-case log-loss)

In [20]:

```
# we need to generate 9 numbers and the sum of numbers should be 1
# one solution is to genarate 9 numbers and divide each of the numbers by their
 sum
# ref: https://stackoverflow.com/a/18662466/4084039
# we create a output array that has exactly same size as the CV data
predicted_y = np.zeros((test_len,2))
for i in range(test_len):
    rand_probs = np.random.rand(1,2)
    predicted_y[i] = ((rand_probs/sum(sum(rand_probs)))[0])
print("Log loss on Test Data using Random Model",log_loss(y_test, predicted_y, e
ps=1e-15))

predicted_y =np.argmax(predicted_y, axis=1)
plot_confusion_matrix(y_test, predicted_y)
```

```
Log loss on Test Data using Random Model 0.8861586593233449
```



In [21]:

```
def plot(alpha,log_error_array):
    fig, ax = plt.subplots(figsize =(10,10))
    a = np.arange(len(alpha))
    ax.plot(a, log_error_array,c='g')
    for i, txt in enumerate(np.round(log_error_array,3)):
        ax.annotate((a[i],np.round(txt,3)), (a[i],log_error_array[i]))
    plt.grid()
    ax.set_xticks(a)
    ax.set_xticklabels(alpha)
    plt.title("Cross Validation Error for each alpha")
    plt.xlabel("Alpha i's")
    plt.ylabel("Error measure")
    plt.show()
```

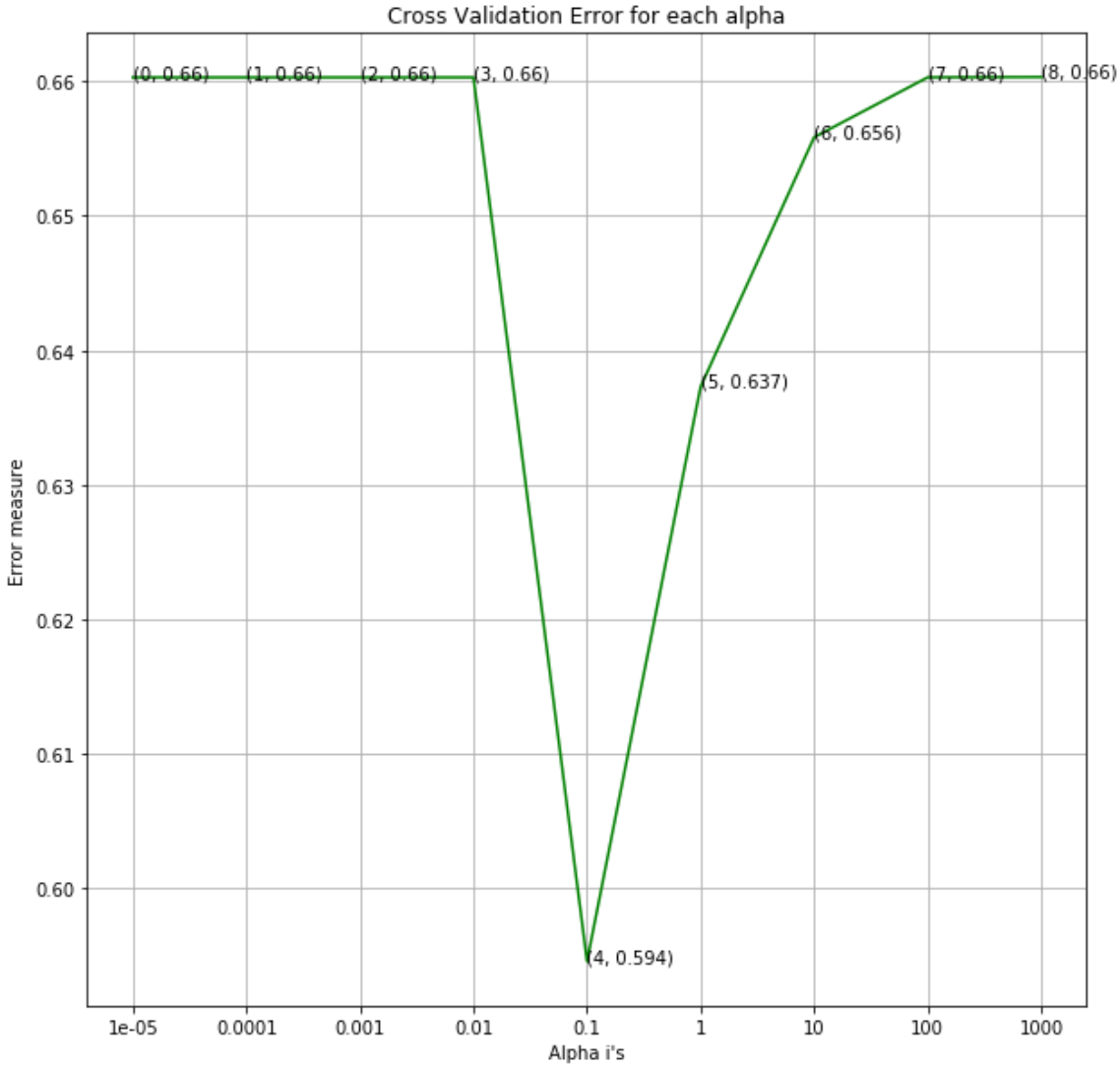
A1

Logistic Regression with hyperparameter tuning

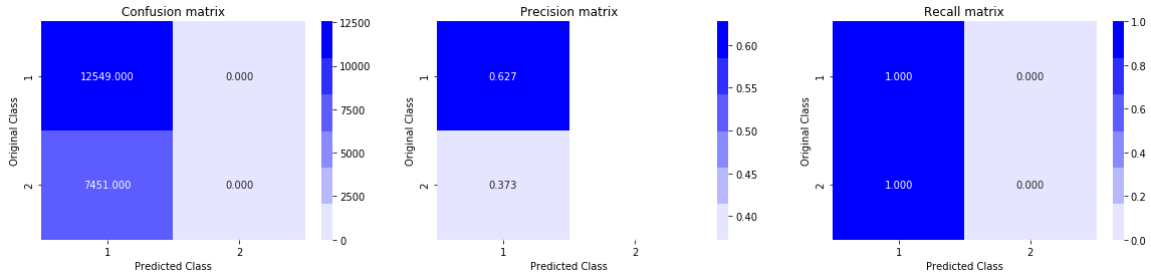
In [26]:

```
alpha = [10 ** x for x in range(-5, 4)]

log_error_array=[]
for i in alpha:
    clf = SGDClassifier(alpha=i, penalty='l1', loss='log', random_state=42)
    clf.fit(X_train, y_train)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(X_train, y_train)
    predict_y = sig_clf.predict_proba(X_cv)
    log_error_array.append(log_loss(y_cv, predict_y, labels=clf.classes_, eps=1e
-15))
    print('For values of alpha = ', i, "The log loss is:",log_loss(y_cv, predict
_y, labels=clf.classes_, eps=1e-15))

plot(alpha,log_error_array)


best_alpha = np.argmin(log_error_array)
clf = SGDClassifier(alpha=alpha[best_alpha], penalty='l2', loss='log', random_st
ate=42)
clf.fit(X_train, y_train)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(X_train, y_train)

predict_y = sig_clf.predict_proba(X_train)
print('For values of best alpha = ', alpha[best_alpha], "The train log loss is:"
,log_loss(y_train, predict_y, labels=clf.classes_, eps=1e-15))
predict_y = sig_clf.predict_proba(X_test)
print('For values of best alpha = ', alpha[best_alpha], "The test log loss is:",
log_loss(y_test, predict_y, labels=clf.classes_, eps=1e-15))
predicted_y =np.argmax(predict_y,axis=1)
print("Total number of data points :", len(predicted_y))
plot_confusion_matrix(y_test, predicted_y)
```

```
For values of alpha =  1e-05 The log loss is: 0.6603054154438797
For values of alpha =  0.0001 The log loss is: 0.6603054154438797
For values of alpha =  0.001 The log loss is: 0.6603054154438797
For values of alpha =  0.01 The log loss is: 0.6603054154438797
For values of alpha =  0.1 The log loss is: 0.5944988382070094
For values of alpha =  1 The log loss is: 0.6372755971249219
For values of alpha =  10 The log loss is: 0.6558483472136013
For values of alpha =  100 The log loss is: 0.6603099695702691
For values of alpha =  1000 The log loss is: 0.6603297297878117
```


Cross Validation Error for each alpha
(0, 0.66)
(1, 0.66)
(2, 0.66)
(3, 0.66)
(4, 0.594)
(5, 0.637)
(6, 0.656)
(7, 0.66)
(8, 0.66)
0.66
0.65
0.64
0.63
0.62
0.61
0.60
Error measure
1e-05
0.0001
0.001
0.01
0.1
1
10
100
1000
Alpha i's

```
For values of best alpha =  0.1 The train log loss is: 0.66028912413
68474
For values of best alpha =  0.1 The test log loss is: 0.660298898921
0667
Total number of data points : 20000
```

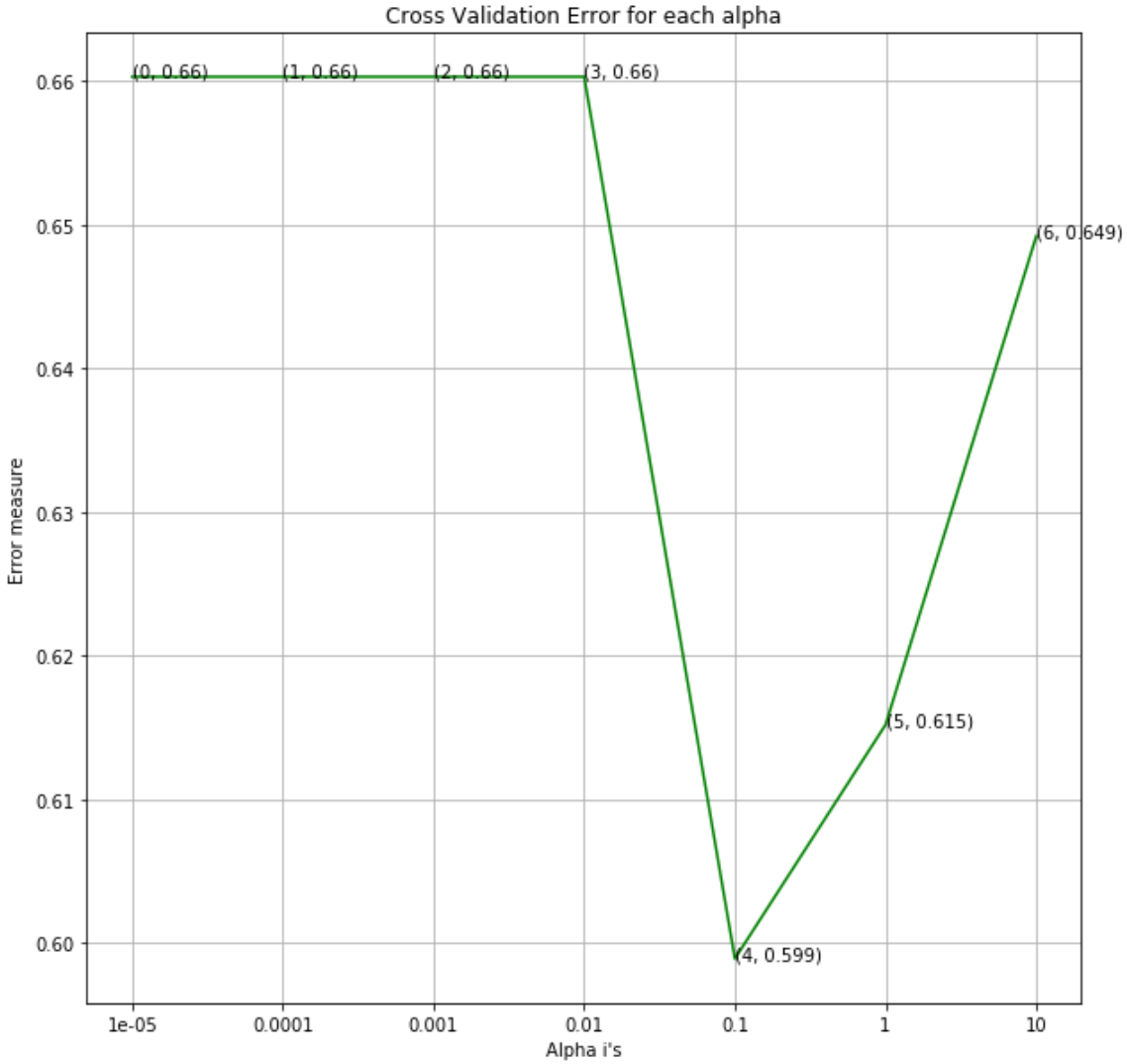


Linear SVM with hyperparameter tuning

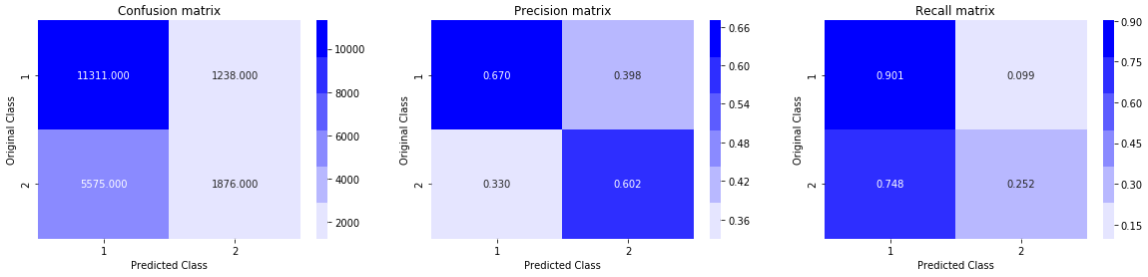
In [27]:

```
alpha = [10 ** x for x in range(-5, 2)]
log_error_array=[]
for i in alpha:
    clf = SGDClassifier(alpha=i, penalty='l1', loss='hinge', random_state=42)
    clf.fit(X_train, y_train)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(X_train, y_train)
    predict_y = sig_clf.predict_proba(X_cv)
    log_error_array.append(log_loss(y_cv, predict_y, labels=clf.classes_, eps=1e
-15))
    print('For values of alpha = ', i, "The log loss is:",log_loss(y_cv, predict
_y, labels=clf.classes_, eps=1e-15))


plot(alpha,log_error_array)

best_alpha = np.argmin(log_error_array)
clf = SGDClassifier(alpha=alpha[best_alpha], penalty='l1', loss='hinge', random_
state=42)
clf.fit(X_train, y_train)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(X_train, y_train)

predict_y = sig_clf.predict_proba(X_train)
print('For values of best alpha = ', alpha[best_alpha], "The train log loss is:"
,log_loss(y_train, predict_y, labels=clf.classes_, eps=1e-15))
predict_y = sig_clf.predict_proba(X_test)
print('For values of best alpha = ', alpha[best_alpha], "The test log loss is:",
log_loss(y_test, predict_y, labels=clf.classes_, eps=1e-15))
predicted_y =np.argmax(predict_y,axis=1)
print("Total number of data points :", len(predicted_y))
plot_confusion_matrix(y_test, predicted_y)
```

```
For values of alpha =  1e-05 The log loss is: 0.6603054154438797
For values of alpha =  0.0001 The log loss is: 0.6603054154438797
For values of alpha =  0.001 The log loss is: 0.6603054154438797
For values of alpha =  0.01 The log loss is: 0.6603054154438797
For values of alpha =  0.1 The log loss is: 0.5989173898417712
For values of alpha =  1 The log loss is: 0.6151992470222541
For values of alpha =  10 The log loss is: 0.6492073783203322
```




```
For values of best alpha =  0.1 The train log loss is: 0.5969050241848052
For values of best alpha =  0.1 The test log loss is: 0.5956379316526482
Total number of data points : 20000
```



A2

In [ ]:

```
import xgboost as xgb
params = {}
params['objective'] = 'binary:logistic'
params['eval_metric'] = 'logloss'
params['eta'] = 0.02
params['max_depth'] = 4

d_train = xgb.DMatrix(X_train, label=y_train)
d_test = xgb.DMatrix(X_test, label=y_test)

watchlist = [(d_train, 'train'), (d_test, 'valid')]

bst = xgb.train(params, d_train, 400, watchlist, early_stopping_rounds=20, verbo
se_eval=10)

xgdmat = xgb.DMatrix(X_train,y_train)
predict_y = bst.predict(d_test)
print("The test log loss is:",log_loss(y_test, predict_y, labels=clf.classes_, e
ps=1e-15))
```

In [28]:

```
#X_train,X_test, y_train, y_test
from xgboost import XGBClassifier
from sklearn.model_selection import RandomizedSearchCV
x_cfl=XGBClassifier()

prams={
     'n_estimators':[100,200,500,1000,2000],
     'max_depth':[3,5,10,100]
}
random_cfl=RandomizedSearchCV(x_cfl,param_distributions=prams,verbose=10,n_jobs=
-1,)
random_cfl.fit(X_train ,y_train)
```

```
Fitting 3 folds for each of 10 candidates, totalling 30 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 4 concurrent w
orkers.
[Parallel(n_jobs=-1)]: Done   5 tasks      | elapsed:  6.4min
[Parallel(n_jobs=-1)]: Done  10 tasks      | elapsed: 36.8min
[Parallel(n_jobs=-1)]: Done  17 tasks      | elapsed: 83.1min
[Parallel(n_jobs=-1)]: Done  27 out of  30 | elapsed: 95.5min remain
ing: 10.6min
[Parallel(n_jobs=-1)]: Done  30 out of  30 | elapsed: 105.2min finis
hed
```

Out[28]:

```
RandomizedSearchCV(cv='warn', error_score='raise-deprecating',
          estimator=XGBClassifier(base_score=0.5, booster='gbtree',
colsample_bylevel=1,
       colsample_bytree=1, gamma=0, learning_rate=0.1, max_delta_ste
p=0,
       max_depth=3, min_child_weight=1, missing=None, n_estimators=1
00,
       n_jobs=1, nthread=None, objective='binary:logistic', random_s
tate=0,
       reg_alpha=0, reg_lambda=1, scale_pos_weight=1, seed=None,
       silent=True, subsample=1),
          fit_params=None, iid='warn', n_iter=10, n_jobs=-1,
          param_distributions={'n_estimators': [100, 200, 500, 1000,
2000], 'max_depth': [3, 5, 10, 100]},
          pre_dispatch='2*n_jobs', random_state=None, refit=True,
          return_train_score='warn', scoring=None, verbose=10)
```

In [29]:

```
print (random_cfl.best_params_)
```

```
{'n_estimators': 2000, 'max_depth': 5}
```

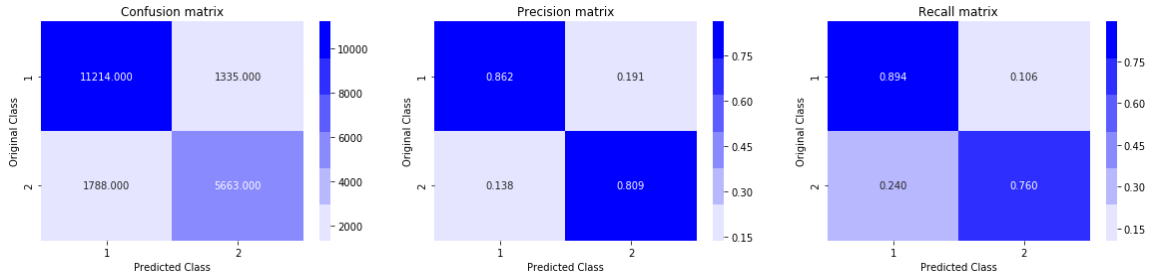
In [30]:

```
best_n_estimators = random_cfl.best_params_['n_estimators']
best_max_depth = random_cfl.best_params_['max_depth']
```

In [31]:

```
x_cfl=XGBClassifier(n_estimators=best_n_estimators,max_depth=best_max_depth)
x_cfl.fit(X_train,y_train,verbose=True)
sig_clf = CalibratedClassifierCV(x_cfl, method="sigmoid")
sig_clf.fit(X_train, y_train)

predict_y = sig_clf.predict_proba(X_train)
print ('For values of best no of estimators = ', best_n_estimators, "The train log loss is:",log_loss(y_train, predict_y))
predict_y = sig_clf.predict_proba(X_test)
print('For values of best no of estimators = ', best_n_estimators, "The test log loss is:",log_loss(y_test, predict_y))
plot_confusion_matrix(y_test,sig_clf.predict(X_test))
```

```
For values of best no of estimators =  2000 The train log loss is:
0.21711923502198788
For values of best no of estimators =  2000 The test log loss is: 0.
3338533534597732
```



Summary

1 . Split the data into train ,cv and test 2 . Apply tfidf vectorizer on 'question1' and 'question2' column separately 3 . Remove the 'question1' and 'question2' column and append the vectorizers to the matrix 4 . Save them to a pickle

Algorithm	Hyperparamter	Log Loss
Logistic Regression	alpha =0.1	0.66
Linear SVM	alpha =0.1	0.595
XgBoost	n_estimators =200 max_depth =5	0.33

In [ ]:

```
```