In [3]:

```
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 sklearn.model_selection import StratifiedKFold
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
```

4. Machine Learning Models

4.1 Reading data from file and storing into sql table

In [4]:

```
#Creating db file from csv
if not os.path.isfile('train.db'):
    disk_engine = create_engine('sqlite:///train.db')
    start = dt.datetime.now()
    chunksize = 180000
    j = 0
    index_start = 1
    for df in pd.read_csv('final_features.csv', names=['Unnamed: 0','id','is_duplicate','cwc_min','
cwc_max','csc_min','csc_max','ctc_min','ctc_max','last_word_eq','first_word_eq','abs_len_diff','me
an_len','token_set_ratio','token_sort_ratio','fuzz_ratio','fuzz_partial_ratio','longest_substr_rati
o','freq_qid1','freq_qid2','q1len','q2len','q1_n_words','q2_n_words','word_Common','word_Total','w
ord_share','freq_q1+q2','freq_q1-
q2','0_x','1_x','2_x','3_x','4_x','5_x','6_x','7_x','8_x','9_x','10_x','11_x','12_x','13_x','14_x',
'15_x','16_x','17_x','18_x','19_x','20_x','21_x','22_x','23_x','24_x','25_x','26_x','27_x','28_x','
29_x','30_x','31_x','32_x','33_x','34_x','35_x','36_x','37_x','38_x','39_x','40_x','41_x','42_x','4
```

```
3_x','44_x','45_x','46_x','47_x','48_x','49_x','50_x','51_x','52_x','53_x','54_x','55_x','56_x','57
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','86_x','87_x','88_x','89_x','90_x','91_x','92_x','93_x','94_x','95_x','96_x','97_x','98_x','99_x'
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9_x','370_x','371_x','372_x','373_x','374_x','375_x','376_x','377_x','378_x','379_x','380_x','381_
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,'13_y','14_y','15_y','16_y','17_y','18_y','19_y','20_y','21_y','22_y','23_y','24_y','25_y','26_y',
'27_y','28_y','29_y','30_y','31_y','32_y','33_y','34_y','35_y','36_y','37_y','38_y','39_y','40_y','
41_y','42_y','43_y','44_y','45_y','46_y','47_y','48_y','49_y','50_y','51_y','52_y','53_y','54_y','5
5_y','56_y','57_y','58_y','59_y','60_y','61_y','62_y','63_y','64_y','65_y','66_y','67_y','68_y','69
_y','70_y','71_y','72_y','73_y','74_y','75_y','76_y','77_y','78_y','79_y','80_y','81_y','82_y','83_
y','84_y','85_y','86_y','87_y','88_y','89_y','90_y','91_y','92_y','93_y','94_y','95_y','96_y','97_y
','98_y','99_y','100_y','101_y','102_y','103_y','104_y','105_y','106_y','107_y','108_y','109_y','11
0_y','111_y','112_y','113_y','114_y','115_y','116_y','117_y','118_y','119_y','120_y','121_y','122_
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147_y','148_y','149_y','150_y','151_y','152_y','153_y','154_y','155_y','156_y','157_y','158_y','15
9_y','160_y','161_y','162_y','163_y','164_y','165_y','166_y','167_y','168_y','169_y','170_y','171_
y','172_y','173_y','174_y','175_y','176_y','177_y','178_y','179_y','180_y','181_y','182_y','183_y'
,'184_y','185_y','186_y','187_y','188_y','189_y','190_y','191_y','192_y','193_y','194_y','195_y','
196_y','197_y','198_y','199_y','200_y','201_y','202_y','203_y','204_y','205_y','206_y','207_y','20
8_y','209_y','210_y','211_y','212_y','213_y','214_y','215_y','216_y','217_y','218_y','219_y','220_
y','221_y','222_y','223_y','224_y','225_y','226_y','227_y','228_y','229_y','230_y','231_y','232_y'
,'233_y','234_y','235_y','236_y','237_y','238_y','239_y','240_y','241_y','242_y','243_y','244_y','
245_y','246_y','247_y','248_y','249_y','250_y','251_y','252_y','253_y','254_y','255_y','256_y','25
7_y','258_y','259_y','260_y','261_y','262_y','263_y','264_y','265_y','266_y','267_y','268_y','269_
y','270_y','271_y','272_y','273_y','274_y','275_y','276_y','277_y','278_y','279_y','280_y','281_y'
,'282_y','283_y','284_y','285_y','286_y','287_y','288_y','289_y','290_y','291_y','292_y','293_y','
294_y','295_y','296_y','297_y','298_y','299_y','300_y','301_y','302_y','303_y','304_y','305_y','30
6_y','307_y','308_y','309_y','310_y','311_y','312_y','313_y','314_y','315_y','316_y','317_y','318_
y','319_y','320_y','321_y','322_y','323_y','324_y','325_y','326_y','327_y','328_y','329_y','330_y'
,'331_y','332_y','333_y','334_y','335_y','336_y','337_y','338_y','339_y','340_y','341_y','342_y','
343_y','344_y','345_y','346_y','347_y','348_y','349_y','350_y','351_y','352_y','353_y','354_y','35
5_y','356_y','357_y','358_y','359_y','360_y','361_y','362_y','363_y','364_y','365_y','366_y','367_
y','368_y','369_y','370_y','371_y','372_y','373_y','374_y','375_y','376_y','377_y','378_y','379_y'
,'380_y','381_y','382_y','383_y'], chunksize=chunksize, iterator=True, encoding='utf-8', ):
        df.index += index_start
        j+=1
        print('{} rows'.format(j*chunksize))
        df.to_sql('data', disk_engine, if_exists='append')
        index_start = df.index[-1] + 1
```

In [5]:

```
#http://www.sqlitetutorial.net/sqlite-python/create-tables/
def create_connection(db_file):
    """ create a database connection to the SQLite database
        specified by db_file
    :param db_file: database file
    :return: Connection object or None
    """
    try:
        conn = sqlite3.connect(db_file)
        return conn
```

```
        return conn
    except Error as e:
        print(e)

    return None


def checkTableExists(dbcon):
    cursr = dbcon.cursor()
    str = "select name from sqlite_master where type='table'"
    table_names = cursr.execute(str)
    print("Tables in the databse:")
    tables =table_names.fetchall()
    print(tables[0][0])
    return(len(tables))
```

In [6]:

```
read_db = 'train.db'
conn_r = create_connection(read_db)
checkTableExists(conn_r)
conn_r.close()
```

```
Tables in the databse:
data
```

In [7]:

```
# try to sample data according to the computing power you have
if os.path.isfile(read_db):
    conn_r = create_connection(read_db)
    if conn_r is not None:
        # for selecting first 1M rows
        # data = pd.read_sql_query("""SELECT * FROM data LIMIT 100001;""", conn_r)

        # for selecting random points
        data = pd.read_sql_query("SELECT * From data ORDER BY RANDOM() LIMIT 100001;", conn_r)
        conn_r.commit()
        conn_r.close()
```

In [8]:

```
# remove the first row
data.drop(data.index[0], inplace=True)
y_true = data['is_duplicate']
data.drop(['Unnamed: 0', 'id','index','is_duplicate'], axis=1, inplace=True)
```

In [9]:

```
data.head()
```

Out[9]:

	cwc_min	cwc_max	csc_min	csc_max	ctc_min	ctc_max	last_word_eq
1	0.199996000079998	0.166663888935184	0.66664444518516	0.333327777870369	0.374995312558593	0.249997916684028	0.0
2	0.749981250468738	0.749981250468738	0.499975001249937	0.499975001249937	0.666655555740738	0.666655555740738	1.0
3	0.599988000239995	0.249997916684028	0.249993750156246	0.111109876556927	0.444439506227709	0.173912287337881	0.0
4	0.333327777870369	0.285710204139941	0.0	0.0	0.166665277789352	0.142856122456268	0.0
5	0.666655555740738	0.666655555740738	0.499987500312492	0.249996875039062	0.599994000059999	0.428568367368804	0.0

5 rows × 794 columns

4.2 Converting strings to numerics

4.2 Converting strings to numerics

In [10]:

```
# after we read from sql table each entry was read it as a string
# we convert all the features into numaric before we apply any model
cols = list(data.columns)
for i in cols:
    data[i] = data[i].apply(pd.to_numeric)
    print(i)
```

```
cwc_min
cwc_max
csc_min
csc_max
ctc_min
ctc_max
last_word_eq
first_word_eq
abs_len_diff
mean_len
token_set_ratio
token_sort_ratio
fuzz_ratio
fuzz_partial_ratio
longest_substr_ratio
freq_qid1
freq_qid2
q1len
q2len
q1_n_words
q2_n_words
word_Common
word_Total
word_share
freq_q1+q2
freq_q1-q2
0_x
1_x
2_x
3_x
4_x
5_x
6_x
7_x
8_x
9_x
10_x
11_x
12_x
13_x
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In [11]:

```
# https://stackoverflow.com/questions/7368789/convert-all-strings-in-a-list-to-int
y_true = list(map(int, y_true.values))
```

4.3 Random train test split(70:30)

In [12]:

```
X_train,X_test, y_train, y_test = train_test_split(data, y_true, stratify=y_true, test_size=0.3)
```

In [13]:

```
print("Number of data points in train data :",X_train.shape)
print("Number of data points in test data :",X_test.shape)
```

```
Number of data points in train data : (70000, 794)
Number of data points in test data : (30000, 794)
```

In [14]:

```
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])/test_len)
```

```
---------- Distribution of output variable in train data ----------
Class 0:  0.6319285714285714 Class 1:  0.36807142857142855
---------- Distribution of output variable in train data ----------
```

```
Class 0:  0.36806666666666665 Class 1:  0.36806666666666665
```

In [15]:

```python
# 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)
    # C = 9,9 matrix, each cell (i,j) represents number of points of class i are predicted class j

    A =(((C.T)/(C.sum(axis=1))).T)
    #divid each element of the confusion matrix with the sum of elements in that column

    # C = [[1, 2],
    #     [3, 4]]
    # C.T = [[1, 3],
    #        [2, 4]]
    # C.sum(axis = 1)  axis=0 corresonds to columns and axis=1 corresponds to rows in two
diamensional array
    # C.sum(axix =1) = [[3, 7]]
    # ((C.T)/(C.sum(axis=1))) = [[1/3, 3/7]
    #                            [2/3, 4/7]]

    # ((C.T)/(C.sum(axis=1))).T = [[1/3, 2/3]
    #                            [3/7, 4/7]]
    # sum of row elements = 1

    B =(C/C.sum(axis=0))
    #divid each element of the confusion matrix with the sum of elements in that row
    # C = [[1, 2],
    #     [3, 4]]
    # C.sum(axis = 0)  axis=0 corresonds to columns and axis=1 corresponds to rows in two
diamensional array
    # C.sum(axix =0) = [[4, 6]]
    # (C/C.sum(axis=0)) = [[1/4, 2/6],
    #                       [3/4, 4/6]]
    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()
```

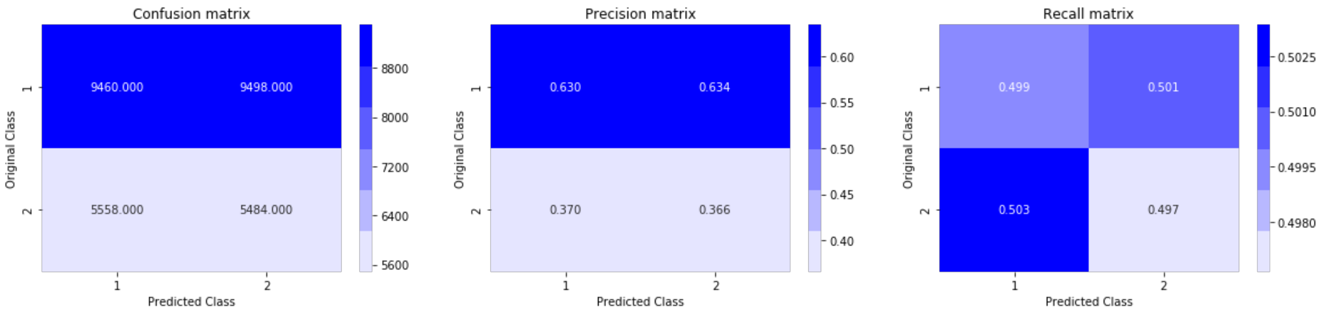
4.4 Building a random model (Finding worst-case log-loss)

In [16]:

```python
# 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, eps=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 0.8920980072030672
```



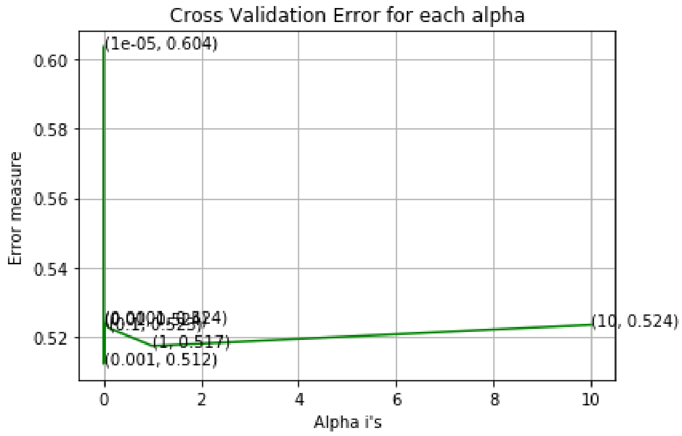
4.4 Logistic Regression with hyperparameter tuning

In [17]:

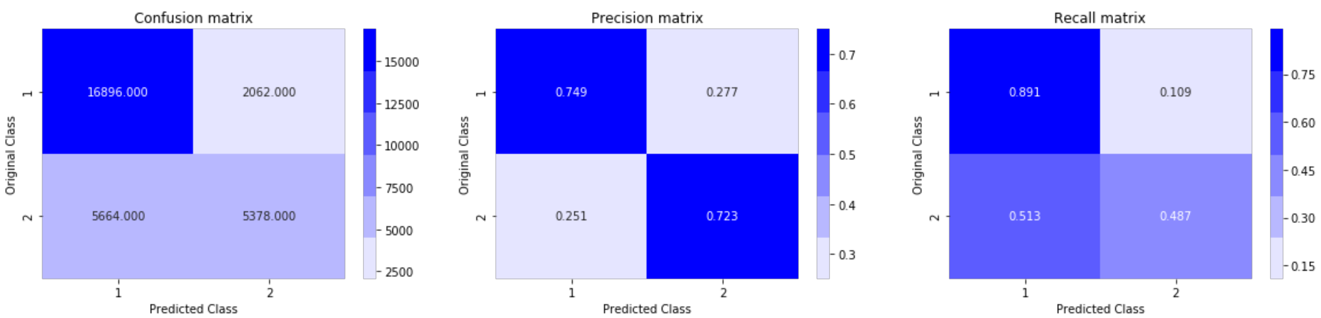
```
alpha = [10 ** x for x in range(-5, 2)] # hyperparam for SGD classifier.

# read more about SGDClassifier() at http://scikit-
learn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html
# ------------------------------
# default parameters
# SGDClassifier(loss='hinge', penalty='l2', alpha=0.0001, l1_ratio=0.15, fit_intercept=True, max_i
ter=None, tol=None,
# shuffle=True, verbose=0, epsilon=0.1, n_jobs=1, random_state=None, learning_rate='optimal', eta0
=0.0, power_t=0.5,
# class_weight=None, warm_start=False, average=False, n_iter=None)

# some of methods
# fit(X, y[, coef_init, intercept_init, …]) Fit linear model with Stochastic Gradient Descent.
# predict(X) Predict class labels for samples in X.

#-------------------------------
# video link:
#------------------------------


log_error_array=[]
for i in alpha:
    clf = SGDClassifier(alpha=i, penalty='l2', 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_test)
    log_error_array.append(log_loss(y_test, predict_y, labels=clf.classes_, eps=1e-15))
    print('For values of alpha = ', i, "The log loss is:",log_loss(y_test, predict_y, labels=clf.cl
asses_, eps=1e-15))

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


best_alpha = np.argmin(log_error_array)
clf = SGDClassifier(alpha=alpha[best_alpha], penalty='l2', 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_train)
```

```python
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: 0.6035913054302467
For values of alpha =  0.0001 The log loss is: 0.5243625576325577
For values of alpha =  0.001 The log loss is: 0.5122626091429161
For values of alpha =  0.01 The log loss is: 0.5241346914793784
For values of alpha =  0.1 The log loss is: 0.5226398430372254
For values of alpha =  1 The log loss is: 0.5174211365837058
For values of alpha =  10 The log loss is: 0.5235052874500619
```




```
For values of best alpha =  0.001 The train log loss is: 0.505494765793637
For values of best alpha =  0.001 The test log loss is: 0.5122626091429161
Total number of data points : 30000
```



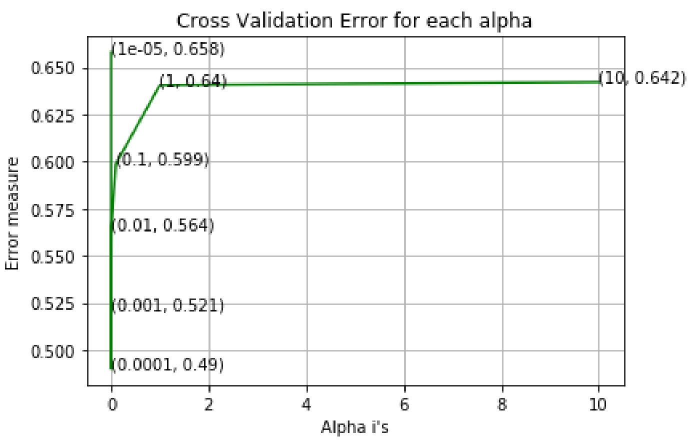
4.5 Linear SVM with hyperparameter tuning

In [18]:

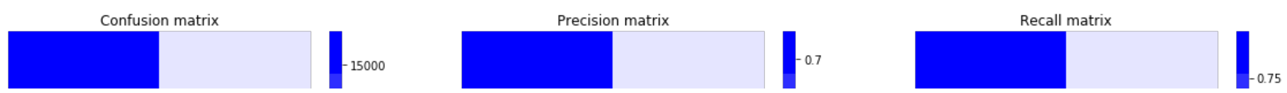
```python
alpha = [10 ** x for x in range(-5, 2)] # hyperparam for SGD classifier.

# read more about SGDClassifier() at http://scikit-learn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html
# ------------------------------
# default parameters
# SGDClassifier(loss='hinge', penalty='l2', alpha=0.0001, l1_ratio=0.15, fit_intercept=True, max_iter=None, tol=None,
# shuffle=True, verbose=0, epsilon=0.1, n_jobs=1, random_state=None, learning_rate='optimal', eta0=0.0, power_t=0.5,
# class_weight=None, warm_start=False, average=False, n_iter=None)

# some of methods
# fit(X, y[, coef_init, intercept_init, …]) Fit linear model with Stochastic Gradient Descent.
# predict(X) Predict class labels for samples in X.

#-------------------------------
```

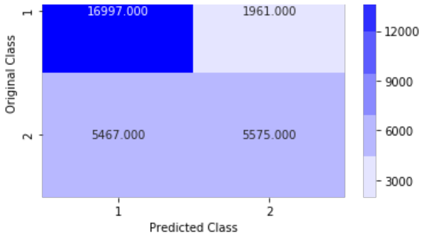
```
# video link:
#------------------------------


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_test)
    log_error_array.append(log_loss(y_test, predict_y, labels=clf.classes_, eps=1e-15))
    print('For values of alpha = ', i, "The log loss is:",log_loss(y_test, predict_y, labels=clf.cl
asses_, eps=1e-15))

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


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, p
redict_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)
```

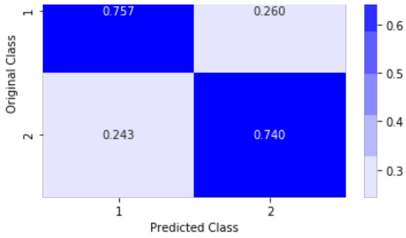
```
For values of alpha =  1e-05 The log loss is: 0.6579187053993628
For values of alpha =  0.0001 The log loss is: 0.489938923497778
For values of alpha =  0.001 The log loss is: 0.5214825234723068
For values of alpha =  0.01 The log loss is: 0.5642511907598364
For values of alpha =  0.1 The log loss is: 0.598593674111375
For values of alpha =  1 The log loss is: 0.640443364230696
For values of alpha =  10 The log loss is: 0.6420695451380629
```

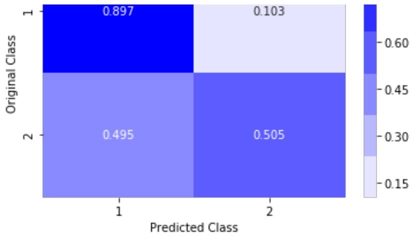



```
For values of best alpha =  0.0001 The train log loss is: 0.4784507404577099
For values of best alpha =  0.0001 The test log loss is: 0.489938923497778
Total number of data points : 30000
```









4.6 XGBoost

In [19]:

```
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, verbose_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_, eps=1e-15))
```

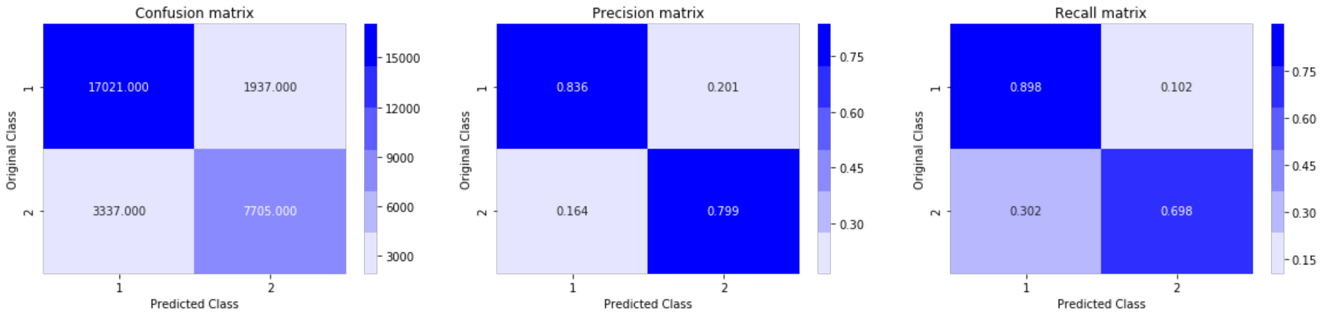
```
[0] train-logloss:0.68484 valid-logloss:0.684882
Multiple eval metrics have been passed: 'valid-logloss' will be used for early stopping.

Will train until valid-logloss hasn't improved in 20 rounds.
[10] train-logloss:0.616115 valid-logloss:0.616505
[20] train-logloss:0.564948 valid-logloss:0.565475
[30] train-logloss:0.526655 valid-logloss:0.527422
[40] train-logloss:0.496822 valid-logloss:0.497844
[50] train-logloss:0.473779 valid-logloss:0.475191
[60] train-logloss:0.455329 valid-logloss:0.456965
[70] train-logloss:0.44052 valid-logloss:0.442376
[80] train-logloss:0.428356 valid-logloss:0.43041
[90] train-logloss:0.418476 valid-logloss:0.420766
[100] train-logloss:0.410409 valid-logloss:0.412846
[110] train-logloss:0.403529 valid-logloss:0.406185
[120] train-logloss:0.397776 valid-logloss:0.400636
[130] train-logloss:0.392836 valid-logloss:0.395936
[140] train-logloss:0.388292 valid-logloss:0.391676
[150] train-logloss:0.384757 valid-logloss:0.388449
[160] train-logloss:0.38155 valid-logloss:0.385492
[170] train-logloss:0.37865 valid-logloss:0.382863
[180] train-logloss:0.376222 valid-logloss:0.38061
[190] train-logloss:0.373858 valid-logloss:0.378418
[200] train-logloss:0.371746 valid-logloss:0.376525
[210] train-logloss:0.369602 valid-logloss:0.374613
[220] train-logloss:0.367389 valid-logloss:0.372679
[230] train-logloss:0.365485 valid-logloss:0.371085
[240] train-logloss:0.363611 valid-logloss:0.369498
[250] train-logloss:0.361767 valid-logloss:0.367944
[260] train-logloss:0.360015 valid-logloss:0.366558
[270] train-logloss:0.358499 valid-logloss:0.365352
[280] train-logloss:0.357023 valid-logloss:0.364254
[290] train-logloss:0.35554 valid-logloss:0.363127
[300] train-logloss:0.354104 valid-logloss:0.362084
[310] train-logloss:0.352855 valid-logloss:0.361177
[320] train-logloss:0.351566 valid-logloss:0.360249
[330] train-logloss:0.350334 valid-logloss:0.359345
[340] train-logloss:0.349123 valid-logloss:0.358529
[350] train-logloss:0.347998 valid-logloss:0.35775
[360] train-logloss:0.346989 valid-logloss:0.357056
[370] train-logloss:0.345849 valid-logloss:0.356341
[380] train-logloss:0.344787 valid-logloss:0.355725
```

```
[390] train-logloss:0.343777 valid-logloss:0.355069
[399] train-logloss:0.342925 valid-logloss:0.354573
The test log loss is: 0.35457332921151535
```

In [20]:

```
predicted_y =np.array(predict_y>0.5,dtype=int)
print("Total number of data points :", len(predicted_y))
plot_confusion_matrix(y_test, predicted_y)
```

```
Total number of data points : 30000
```



5. Assignments

1. Try out models (Logistic regression, Linear-SVM) with simple TF-IDF vectors instead of TD_IDF weighted word2Vec.
2. Hyperparameter tune XgBoost using RandomSearch to reduce the log-loss.

In [21]:

```
df = pd.read_csv('train.csv')
```

In [22]:

```
df.head()
```

Out[22]:

	id	qid1	qid2	question1	question2	is_duplicate
0	0	1	2	What is the step by step guide to invest in sh...	What is the step by step guide to invest in sh...	0
1	1	3	4	What is the story of Kohinoor (Koh-i-Noor) Dia...	What would happen if the Indian government sto...	0
2	2	5	6	How can I increase the speed of my internet co...	How can Internet speed be increased by hacking...	0
3	3	7	8	Why am I mentally very lonely? How can I solve...	Find the remainder when [math]23^{24}[/math] i...	0
4	4	9	10	Which one dissolve in water quikly sugar, salt...	Which fish would survive in salt water?	0

In [23]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 404290 entries, 0 to 404289
Data columns (total 6 columns):
id              404290 non-null int64
qid1            404290 non-null int64
qid2            404290 non-null int64
question1       404289 non-null object
question2       404288 non-null object
is_duplicate    404290 non-null int64
dtypes: int64(4), object(2)
memory usage: 18.5+ MB
```

In [51]:

```
nlpfeatures = pd.read_csv('nlp_features_train.csv', encoding = 'latin-1')
```

In [53]:

```
nlpfeatures.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 404290 entries, 0 to 404289
Data columns (total 21 columns):
id                      404290 non-null int64
qid1                    404290 non-null int64
qid2                    404290 non-null int64
question1               404276 non-null object
question2               404284 non-null object
is_duplicate            404290 non-null int64
cwc_min                 404290 non-null float64
cwc_max                 404290 non-null float64
csc_min                 404290 non-null float64
csc_max                 404290 non-null float64
ctc_min                 404290 non-null float64
ctc_max                 404290 non-null float64
last_word_eq            404290 non-null float64
first_word_eq           404290 non-null float64
abs_len_diff            404290 non-null float64
mean_len                404290 non-null float64
token_set_ratio         404290 non-null int64
token_sort_ratio        404290 non-null int64
fuzz_ratio              404290 non-null int64
fuzz_partial_ratio      404290 non-null int64
longest_substr_ratio    404290 non-null float64
dtypes: float64(11), int64(8), object(2)
memory usage: 64.8+ MB
```

In [54]:

```
# Filling the null values with ' '
nlpfeatures = nlpfeatures.fillna('')
nan_rows = nlpfeatures[nlpfeatures.isnull().any(1)]
```

In [55]:

```
nlpfeatures.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 404290 entries, 0 to 404289
Data columns (total 21 columns):
id                      404290 non-null int64
qid1                    404290 non-null int64
qid2                    404290 non-null int64
question1               404290 non-null object
question2               404290 non-null object
is_duplicate            404290 non-null int64
cwc_min                 404290 non-null float64
cwc_max                 404290 non-null float64
csc_min                 404290 non-null float64
csc_max                 404290 non-null float64
ctc_min                 404290 non-null float64
ctc_max                 404290 non-null float64
last_word_eq            404290 non-null float64
first_word_eq           404290 non-null float64
abs_len_diff            404290 non-null float64
mean_len                404290 non-null float64
token_set_ratio         404290 non-null int64
token_sort_ratio        404290 non-null int64
fuzz_ratio              404290 non-null int64
fuzz_partial_ratio      404290 non-null int64
longest_substr_ratio    404290 non-null float64
dtypes: float64(11), int64(8), object(2)
memory usage: 64.8+ MB
```

In [207]:

```
X = nlpfeatures.drop(['is_duplicate', 'id', 'qid1', 'qid2'], axis = 1 )
y = nlpfeatures['is_duplicate']
```

In [208]:

```
X.head()
```

Out[208]:

	question1	question2	cwc_min	cwc_max	csc_min	csc_max	ctc_min	ctc_max	last_word_eq	first_word_eq	abs_len_diff	mea
0	what is the step by step guide to invest in sh...	what is the step by step guide to invest in sh...	0.999980	0.833319	0.999983	0.999983	0.916659	0.785709	0.0	1.0	2.0	
1	what is the story of kohinoor koh i noor dia...	what would happen if the indian government sto...	0.799984	0.399996	0.749981	0.599988	0.699993	0.466664	0.0	1.0	5.0	
2	how can i increase the speed of my internet co...	how can internet speed be increased by hacking...	0.399992	0.333328	0.399992	0.249997	0.399996	0.285712	0.0	1.0	4.0	
3	why am i mentally very lonely how can i solve...	find the remainder when math 23 24 math i...	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0	0.0	2.0	
4	which one dissolve in water quikly sugar salt...	which fish would survive in salt water	0.399992	0.199998	0.999950	0.666644	0.571420	0.307690	0.0	1.0	6.0	

In [209]:

```
X_train,X_test, y_train, y_test = train_test_split(X, y, stratify=y, test_size=0.3)

print("Number of data points in train data :",X_train.shape)
print("Number of data points in test data :",X_test.shape)
```

```
Number of data points in train data : (283003, 17)
Number of data points in test data : (121287, 17)
```

In [210]:

```
vectorizer = TfidfVectorizer(min_df = 3)
X_train_question1_tfidf = vectorizer.fit_transform(X_train['question1'].values)
X_test_question1_tfidf = vectorizer.transform(X_test['question1'].values)
```

In [211]:

```
vectorizer = TfidfVectorizer(min_df = 3)
X_train_question2_tfidf = vectorizer.fit_transform(X_train['question2'].values)
X_test_question2_tfidf = vectorizer.transform(X_test['question2'].values)
```

In [212]:

```
X_train.columns
```

Out[212]:

```
Index(['question1', 'question2', 'cwc_min', 'cwc_max', 'csc_min', 'csc_max',
       'ctc_min', 'ctc_max', 'last_word_eq', 'first_word_eq', 'abs_len_diff',
       'mean_len', 'token_set_ratio', 'token_sort_ratio', 'fuzz_ratio',
       'fuzz_partial_ratio', 'longest_substr_ratio'],
      dtype='object')
```

In [213]:

```
from sklearn.preprocessing import Normalizer
normalizer = Normalizer()
cwc_min_train = normalizer.fit_transform(X_train['cwc_min'].values.reshape(-1,1))
cwc_min_test = normalizer.transform((X_test['cwc_min'].values.reshape(-1,1)))

normalizer = Normalizer()
cwc_max_train = normalizer.fit_transform(X_train['cwc_max'].values.reshape(-1,1))
cwc_max_test = normalizer.transform(X_test['cwc_max'].values.reshape(-1,1))

normalizer = Normalizer()
csc_min_train = normalizer.fit_transform(X_train['csc_min'].values.reshape(-1,1))
csc_min_test = normalizer.transform(X_test['csc_min'].values.reshape(-1,1))

normalizer = Normalizer()
csc_max_train = normalizer.fit_transform(X_train['csc_max'].values.reshape(-1,1))
csc_max_test = normalizer.transform(X_test['csc_max'].values.reshape(-1,1))

normalizer = Normalizer()
ctc_min_train = normalizer.fit_transform(X_train['ctc_min'].values.reshape(-1,1))
ctc_min_test = normalizer.transform(X_test['ctc_min'].values.reshape(-1,1))

normalizer = Normalizer()
ctc_max_train = normalizer.fit_transform(X_train['ctc_max'].values.reshape(-1,1))
ctc_max_test = normalizer.transform(X_test['ctc_max'].values.reshape(-1,1))

normalizer = Normalizer()
last_word_eq_train = normalizer.fit_transform(X_train['last_word_eq'].values.reshape(-1,1))
last_word_eq_test = normalizer.transform(X_test['last_word_eq'].values.reshape(-1,1))

normalizer = Normalizer()
first_word_eq_train = normalizer.fit_transform(X_train['first_word_eq'].values.reshape(-1,1))
first_word_eq_test = normalizer.transform(X_test['first_word_eq'].values.reshape(-1,1))

normalizer = Normalizer()
abs_len_diff_train = normalizer.fit_transform(X_train['abs_len_diff'].values.reshape(-1,1))
abs_len_diff_test = normalizer.transform(X_test['abs_len_diff'].values.reshape(-1,1))

normalizer = Normalizer()
mean_len_train = normalizer.fit_transform(X_train['mean_len'].values.reshape(-1,1))
mean_len_test = normalizer.transform(X_test['mean_len'].values.reshape(-1,1))

normalizer = Normalizer()
token_set_ratio_train = normalizer.fit_transform(X_train['token_set_ratio'].values.reshape(-1,1))
token_set_ratio_test = normalizer.transform(X_test['token_set_ratio'].values.reshape(-1,1))

normalizer = Normalizer()
token_sort_ratio_train = normalizer.fit_transform(X_train['token_sort_ratio'].values.reshape(-1,1))
token_sort_ratio_test = normalizer.transform(X_test['token_sort_ratio'].values.reshape(-1,1))

normalizer = Normalizer()
fuzz_ratio_train = normalizer.fit_transform(X_train['fuzz_ratio'].values.reshape(-1,1))
fuzz_ratio_test = normalizer.transform(X_test['fuzz_ratio'].values.reshape(-1,1))

normalizer = Normalizer()
fuzz_partial_ratio_train = normalizer.fit_transform(X_train['fuzz_partial_ratio'].values.reshape(-1
,1))
fuzz_partial_ratio_test = normalizer.transform(X_test['fuzz_partial_ratio'].values.reshape(-1,1))

normalizer = Normalizer()
longest_substr_ratio_train =
normalizer.fit_transform(X_train['longest_substr_ratio'].values.reshape(-1,1))
longest_substr_ratio_test = normalizer.transform(X_test['longest_substr_ratio'].values.reshape(-1,1
))
```

In [215]:

```
from scipy.sparse import hstack
```

```
X_train = hstack((X_train_question1_tfidf, X_train_question2_tfidf, X_train_normalized,
cwc_min_train, cwc_max_train, csc_min_train, csc_max_train, ctc_min_train, ctc_max_train, last_word
_eq_train, first_word_eq_train, abs_len_diff_train, mean_len_train, token_set_ratio_train, token_so
rt_ratio_train, fuzz_ratio_train, fuzz_partial_ratio_train, longest_substr_ratio_train)).tocsr()
X_test = hstack((X_test_question1_tfidf, X_test_question2_tfidf, X_test_normalized, cwc_min_test,
cwc_max_test, csc_min_test, csc_max_test, ctc_min_test, ctc_max_test, last_word_eq_test,
first_word_eq_test, abs_len_diff_test, mean_len_test, token_set_ratio_test, token_sort_ratio_test,
fuzz_ratio_test, fuzz_partial_ratio_test, longest_substr_ratio_test)).tocsr()
```

In [217]:

```
X_test
```

Out[217]:

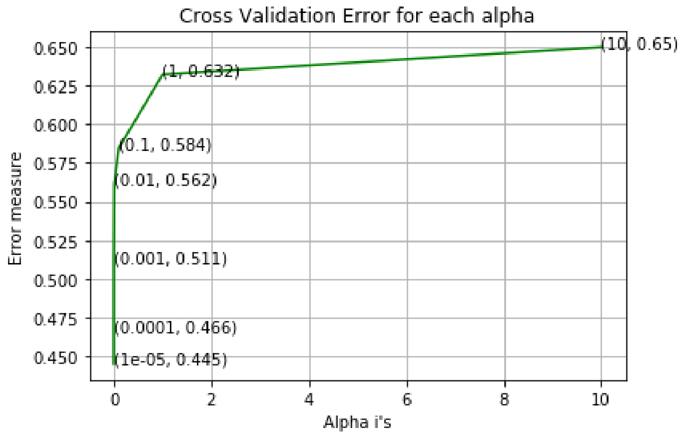
```
<121287x49186 sparse matrix of type '<class 'numpy.float64'>'
 with 4109274 stored elements in Compressed Sparse Row format>
```

In [218]:

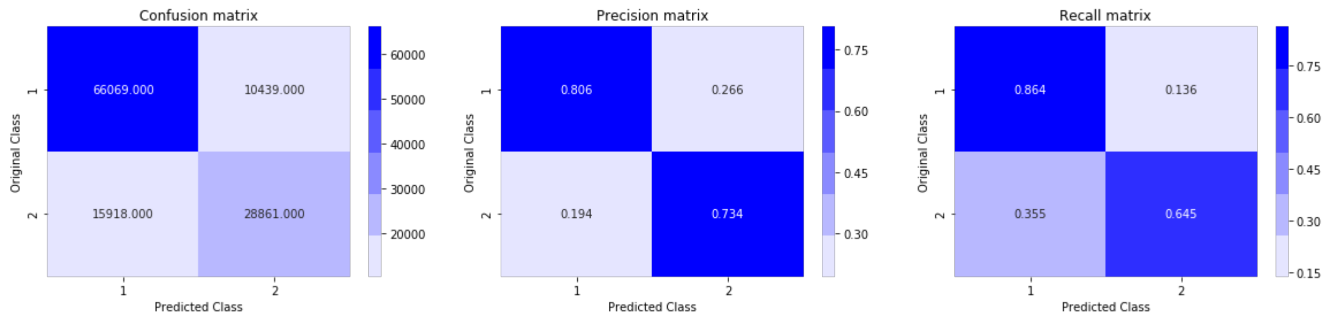
```
alpha = [10 ** x for x in range(-5, 2)] # hyperparam for SGD classifier.

# read more about SGDClassifier() at http://scikit-
learn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html
# ------------------------------
# default parameters
# SGDClassifier(loss='hinge', penalty='l2', alpha=0.0001, l1_ratio=0.15, fit_intercept=True, max_i
ter=None, tol=None,
# shuffle=True, verbose=0, epsilon=0.1, n_jobs=1, random_state=None, learning_rate='optimal', eta0
=0.0, power_t=0.5,
# class_weight=None, warm_start=False, average=False, n_iter=None)

# some of methods
# fit(X, y[, coef_init, intercept_init, …]) Fit linear model with Stochastic Gradient Descent.
# predict(X) Predict class labels for samples in X.

#-------------------------------
# video link:
#------------------------------


log_error_array=[]
for i in alpha:
    clf = SGDClassifier(alpha=i, penalty='l2', 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_test)
    log_error_array.append(log_loss(y_test, predict_y, labels=clf.classes_, eps=1e-15))
    print('For values of alpha = ', i, "The log loss is:",log_loss(y_test, predict_y, labels=clf.cl
asses_, eps=1e-15))

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


best_alpha = np.argmin(log_error_array)
clf = SGDClassifier(alpha=alpha[best_alpha], penalty='l2', 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_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, p
redict_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: 0.44526254212405547
For values of alpha =  0.0001 The log loss is: 0.4657760298871082
For values of alpha =  0.001 The log loss is: 0.5111258098893877
For values of alpha =  0.01 The log loss is: 0.5615102228944616
For values of alpha =  0.1 The log loss is: 0.5843290819582394
For values of alpha =  1 The log loss is: 0.6320509407231564
For values of alpha =  10 The log loss is: 0.6496734532520676
```




```
For values of best alpha =  1e-05 The train log loss is: 0.41816336872986865
For values of best alpha =  1e-05 The test log loss is: 0.44526254212405547
Total number of data points : 121287
```

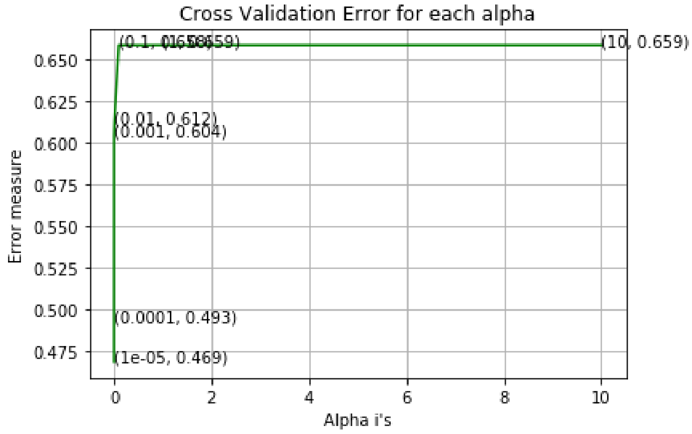


In [219]:

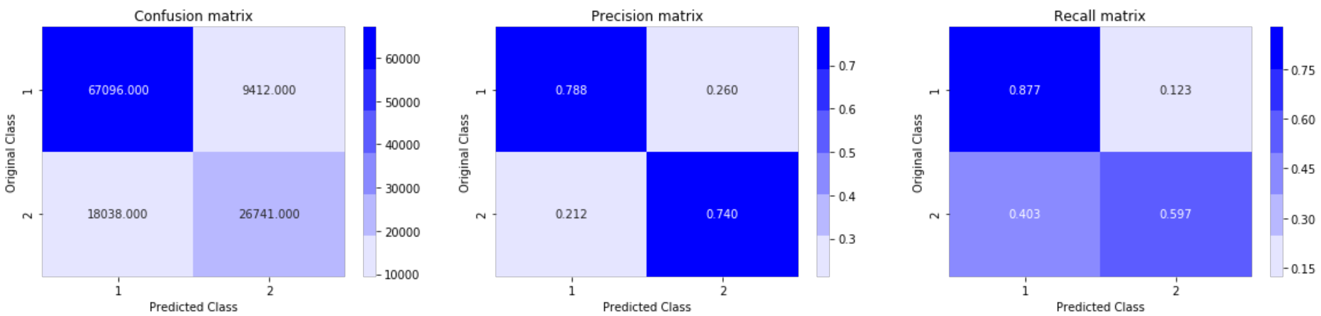
```
alpha = [10 ** x for x in range(-5, 2)] # hyperparam for SGD classifier.

# read more about SGDClassifier() at http://scikit-
learn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html
# ------------------------------
# default parameters
# SGDClassifier(loss='hinge', penalty='l2', alpha=0.0001, l1_ratio=0.15, fit_intercept=True, max_i
ter=None, tol=None,
# shuffle=True, verbose=0, epsilon=0.1, n_jobs=1, random_state=None, learning_rate='optimal', eta0
=0.0, power_t=0.5,
# class_weight=None, warm_start=False, average=False, n_iter=None)

# some of methods
# fit(X, y[, coef_init, intercept_init, …]) Fit linear model with Stochastic Gradient Descent.
# predict(X) Predict class labels for samples in X.

#-------------------------------
# video link:
#------------------------------


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_test)
    log_error_array.append(log_loss(y_test, predict_y, labels=clf.classes_, eps=1e-15))
    print('For values of alpha = ', i, "The log loss is:",log_loss(y_test, predict_y, labels=clf.cl
asses_, eps=1e-15))

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


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, p
redict_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: 0.4685881799916419
For values of alpha =  0.0001 The log loss is: 0.4925769044146379
For values of alpha =  0.001 The log loss is: 0.6044662447443142
For values of alpha =  0.01 The log loss is: 0.612134697211296
For values of alpha =  0.1 The log loss is: 0.6584974344080787
For values of alpha =  1 The log loss is: 0.658527825632271
For values of alpha =  10 The log loss is: 0.6585278256322541
```



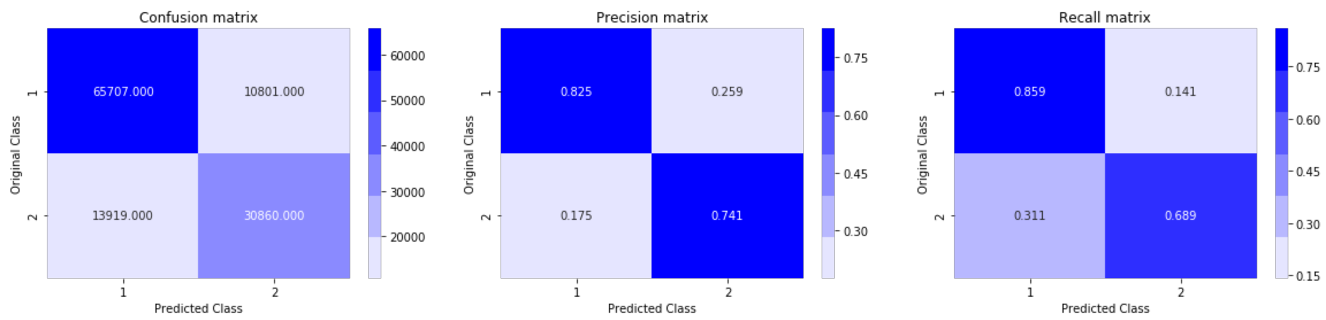

```
For values of best alpha =  1e-05 The train log loss is: 0.4494262203000246
For values of best alpha =  1e-05 The test log loss is: 0.4685881799916419
Total number of data points : 121287
```



In [238]:

```
predicted_y =np.array(predict_y>0.5,dtype=int)
print("Total number of data points :", len(predicted_y))
plot_confusion_matrix(y_test, predicted_y)
```

Total number of data points : 121287



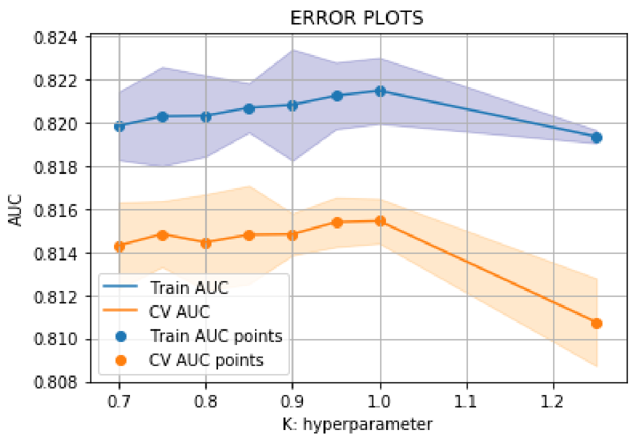
In [250]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
#https://www.kaggle.com/phunter/xgboost-with-gridsearchcv
#The above link was looked at to implement xgboost with gridsearchcv
xgb_model = xgb.XGBClassifier()

#brute force scan for all parameters, here are the tricks
#usually max_depth is 6,7,8
#learning rate is around 0.05, but small changes may make big diff
#tuning min_child_weight subsample colsample_bytree can have
#much fun of fighting against overfit
#n_estimators is how many round of boosting
#finally, ensemble xgboost with multiple seeds may reduce variance
parameters = {'nthread':[4], #when use hyperthread, xgboost may become slower
              'objective':['binary:logistic'],
              'learning_rate': [0.7, 0.75, 0.8, 0.85, 0.9, 0.95, 1, 1.25], #so called `eta` value
              'max_depth': [6],
              'min_child_weight': [11],
              'silent': [1],
              'subsample': [0.8],
              'colsample_bytree': [0.7],
              'n_estimators': [10], #number of trees, change it to 1000 for better results
              'missing':[-999],
              'seed': [1337]}


clf = GridSearchCV(xgb_model, parameters, n_jobs=5,
                   cv=3,
                   scoring='roc_auc',
                   verbose=2, refit=True)
clf.fit(X_train, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']

plt.plot(parameters['learning_rate'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['learning_rate'],train_auc - train_auc_std,train_auc +
train_auc_std,alpha=0.2,color='darkblue')

plt.plot(parameters['learning_rate'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['learning_rate'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.
2,color='darkorange')

plt.scatter(parameters['learning_rate'], train_auc, label='Train AUC points')
plt.scatter(parameters['learning_rate'], cv_auc, label='CV AUC points')
```

```
plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```

```
Fitting 3 folds for each of 8 candidates, totalling 24 fits
```

```
[Parallel(n_jobs=5)]: Using backend LokyBackend with 5 concurrent workers.
[Parallel(n_jobs=5)]: Done  24 out of  24 | elapsed:   48.1s finished
```



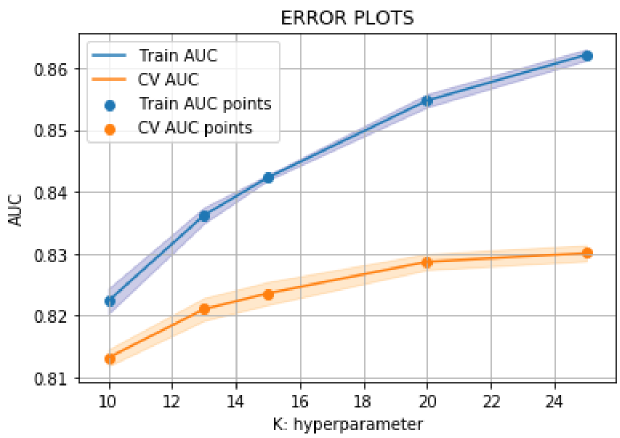
In [242]:

```
# https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.GridSearchCV.html
#https://www.kaggle.com/phunter/xgboost-with-gridsearchcv
#The above link was looked at to implement xgboost with gridsearchcv
xgb_model = xgb.XGBClassifier()

#brute force scan for all parameters, here are the tricks
#usually max_depth is 6,7,8
#learning rate is around 0.05, but small changes may make big diff
#tuning min_child_weight subsample colsample_bytree can have
#much fun of fighting against overfit
#n_estimators is how many round of boosting
#finally, ensemble xgboost with multiple seeds may reduce variance
parameters = {'nthread':[4], #when use hyperthread, xgboost may become slower
              'objective':['binary:logistic'],
              'learning_rate': [0.95], #so called `eta` value
              'max_depth': [10, 13, 15, 20, 25],
              'min_child_weight': [11],
              'silent': [1],
              'subsample': [0.8],
              'colsample_bytree': [0.7],
              'n_estimators': [5], #number of trees, change it to 1000 for better results
              'missing':[-999],
              'seed': [1337]}


clf = GridSearchCV(xgb_model, parameters, n_jobs=5,
                   cv=3,
                   scoring='roc_auc',
                   verbose=2, refit=True)
clf.fit(X_train, y_train)

train_auc= clf.cv_results_['mean_train_score']
train_auc_std= clf.cv_results_['std_train_score']
cv_auc = clf.cv_results_['mean_test_score']
cv_auc_std= clf.cv_results_['std_test_score']

plt.plot(parameters['max_depth'], train_auc, label='Train AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
plt.gca().fill_between(parameters['max_depth'],train_auc - train_auc_std,train_auc + train_auc_std
,alpha=0.2,color='darkblue')

plt.plot(parameters['max_depth'], cv_auc, label='CV AUC')
# this code is copied from here: https://stackoverflow.com/a/48803361/4084039
```

```
plt.gca().fill_between(parameters['max_depth'],cv_auc - cv_auc_std,cv_auc + cv_auc_std,alpha=0.2,co
lor='darkorange')

plt.scatter(parameters['max_depth'], train_auc, label='Train AUC points')
plt.scatter(parameters['max_depth'], cv_auc, label='CV AUC points')


plt.legend()
plt.xlabel("K: hyperparameter")
plt.ylabel("AUC")
plt.title("ERROR PLOTS")
plt.grid()
plt.show()
```

```
Fitting 3 folds for each of 5 candidates, totalling 15 fits
```

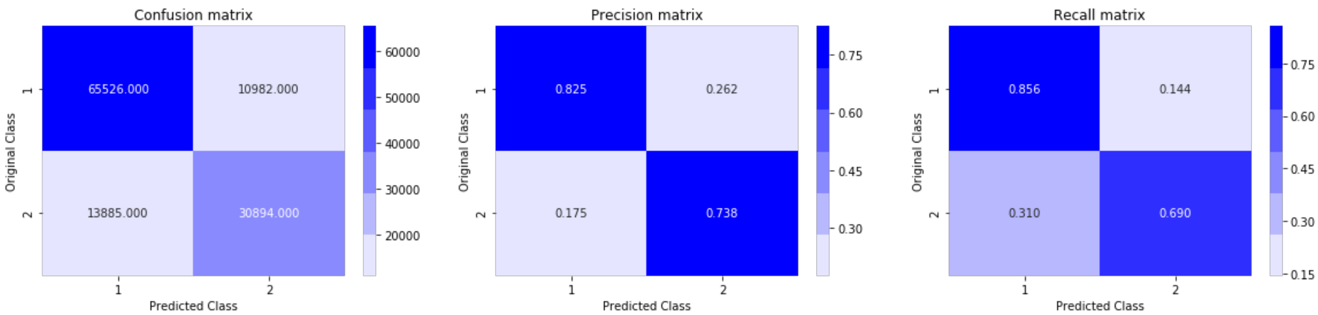
```
[Parallel(n_jobs=5)]: Using backend LokyBackend with 5 concurrent workers.
[Parallel(n_jobs=5)]: Done  15 out of  15 | elapsed:   35.3s finished
```



In [245]:

```
predicted_y =np.array(predict_y>0.5,dtype=int)
print("Total number of data points :", len(predicted_y))
plot_confusion_matrix(y_test, predicted_y)
```

```
Total number of data points : 121287
```



In [257]:

```
xg_reg = xgb.XGBRegressor(objective ='reg:linear', colsample_bytree = 0.5, learning_rate = 0.95,
                max_depth = 5, alpha = 10, n_estimators = 1000)
xg_reg.fit(X_train, y_train)
predict_y = xg_reg.predict(X_test)
```

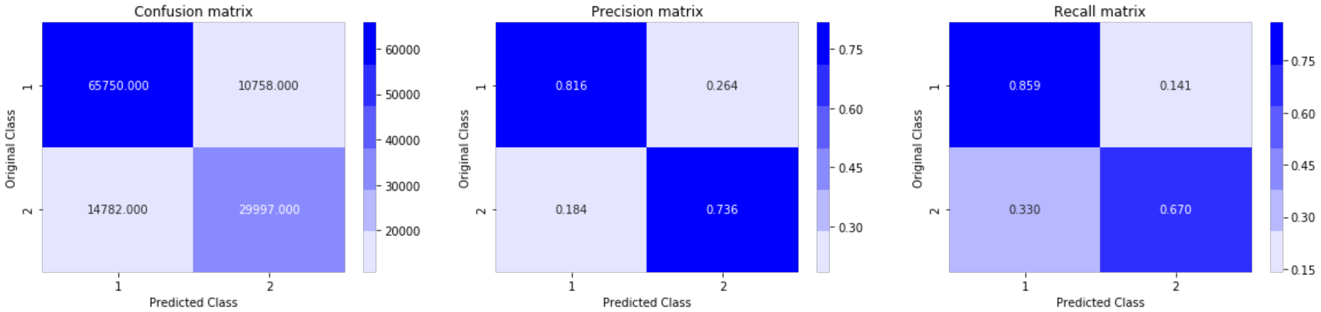
```
[22:18:02] WARNING: src/objective/regression_obj.cu:152: reg:linear is now deprecated in favor of
reg:squarederror.
```

In [258]:

```
predicted_y =np.array(predict_y>0.5,dtype=int)
```

```
print("Total number of data points :", len(predicted_y))
plot_confusion_matrix(y_test, predicted_y)
```

```
Total number of data points : 121287
```



In [ ]:

```
from prettytable import PrettyTable
x = PrettyTable()
x.field_names = ['Model', 'Train Error', 'Cross Validation Error', ]
x.add_row(["Logistic Regression", 0.418, 0.445])
x.add_row(["Linear Support Vector Machine", 0.449, 0.468])
x.add_row(["Gradient Boosting Decision Tree", 0.391, 0.412 ])
print(x)
```