In [3]:

```
import pandas as pd
import matplotlib.pyplot as plt
import re
import time
import warnings
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 sklearn.linear_model import SGDClassifier
from imblearn.over_sampling import SMOTE
from collections import Counter
from scipy.sparse import hstack
from sklearn.multiclass import OneVsRestClassifier
from sklearn.svm import SVC
from sklearn import model_selection
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
warnings.filterwarnings("ignore")

from mlxtend.classifier import StackingClassifier

from sklearn import model_selection
from sklearn.linear_model import LogisticRegression
```

```
Using TensorFlow backend.
```

In [199]:

```
#!pip install imblearn
```

Reading Dataset

In [5]:

```
data = pd.read_csv('train.csv')
print('Number of data points : ', data.shape[0])
print('Number of features : ', data.shape[1])
print('Features : ', data.columns.values)
data.head()
```

```
Number of data points :  5279
Number of features :  4
Features :  ['unique_hash' 'text' 'drug' 'sentiment']
```

Out[5]:

	unique_hash	text	drug	sentiment
0	2e180be4c9214c1f5ab51fd8cc32bc80c9f612e0	Autoimmune diseases tend to come in clusters. ...	gilenya	2
1	9eba8f80e7e20f3a2f48685530748fbfa95943e4	I can completely understand why you'd want to ...	gilenya	2
2	fe809672251f6bd0d986e00380f48d047c7e7b76	Interesting that it only targets S1P-1/5 recep...	fingolimod	2
3	bd22104dfa9ec80db4099523e03fae7a52735eb6	Very interesting, grand merci. Now I wonder wh...	ocrevus	2
4	b227688381f9b25e5b65109dd00f7f895e838249	Hi everybody, My latest MRI results for Brain ...	gilenya	1

In [152]:

```
data_test = pd.read_csv('test.csv')
print('Number of data points : ', data_test.shape[0])
print('Number of features : ', data_test.shape[1])
print('Features : ', data_test.columns.values)
data_test.head()
```

```
Number of data points :  2924
Number of features :  3
Features :  ['unique_hash' 'text' 'drug']
```

Out[152]:

	unique_hash	text	drug
0	9e9a8166b84114aca147bf409f6f956635034c08	256 (previously stable on natalizumab), with 5...	fingolimod
1	e747e6822c867571afe7b907b51f0f2ca67b0e1a	On fingolimod and have been since December 201...	fingolimod
2	50b6d851bcff4f35afe354937949e9948975adf7	Apparently it's shingles! :-/ I do have a few ...	humira
3	7f82ec2176ae6ab0b5d20b5ffc767ac829f384ae	If the Docetaxel doing once a week x3 weeks th...	tagrisso
4	8b37d169dee5bdae27060949242fb54feb6a7f7f	CC, Stelara worked in a matter of days for me....	stelara

Preprocessing of text

In [7]:

```
import nltk
nltk.download('stopwords')
```

```
[nltk_data] Downloading package stopwords to C:\Users\IDM
[nltk_data]     LAB-09\AppData\Roaming\nltk_data...
[nltk_data]   Unzipping corpora\stopwords.zip.
```

Out[7]:

```
True
```

In [153]:

```
# Loading stop words from nltk library
stop_words = set(stopwords.words('english'))


def nlp_preprocessing(total_text, index, column):
    if type(total_text) is not int:
        string = ""
        # replace every special char with space
        total_text = re.sub('[^a-zA-Z0-9\n]', ' ', total_text)
        # replace multiple spaces with single space
        total_text = re.sub('\s+',' ', total_text)
        # converting all the chars into lower-case.
        total_text = total_text.lower()

        for word in total_text.split():
        # if the word is a not a stop word then retain that word from the data
            if not word in stop_words:
                string += word + " "

        data[column][index] = string
```

In [10]:

```
#text processing stage.
start_time = time.clock()
for index, row in data.iterrows():
    if type(row['text']) is str:
        nlp_preprocessing(row['text'], index, 'text')
    else:
        print("there is no text description for id:",index)
print('Time took for preprocessing the text :',time.clock() - start_time, "seconds")
```

```
Time took for preprocessing the text : 390.0765071840001 seconds
```

In [154]:

```
#text processing stage.
start_time = time.clock()
for index, row in data_test.iterrows():
    if type(row['text']) is str:
        nlp_preprocessing(row['text'], index, 'text')
    else:
        print("there is no text description for id:",index)
print('Time took for preprocessing the text :',time.clock() - start_time, "seconds")
```

```
Time took for preprocessing the text : 238.2578997519995 seconds
```

In [162]:

```
data_test.head(5)
```

Out[162]:

	unique_hash	text	drug
0	9e9a8166b84114aca147bf409f6f956635034c08	256 (previously stable on natalizumab), with 5...	fingolimod
1	e747e6822c867571afe7b907b51f0f2ca67b0e1a	On fingolimod and have been since December 201...	fingolimod
2	50b6d851bcff4f35afe354937949e9948975adf7	Apparently it's shingles! :-/ I do have a few ...	humira
3	7f82ec2176ae6ab0b5d20b5ffc767ac829f384ae	If the Docetaxel doing once a week x3 weeks th...	tagrisso
4	8b37d169dee5bdae27060949242fb54feb6a7f7f	CC, Stelara worked in a matter of days for me....	stelara

In [11]:

```
data.head(10)
```

Out[11]:

	unique_hash	text	drug	sentiment
0	2e180be4c9214c1f5ab51fd8cc32bc80c9f612e0	autoimmune diseases tend come clusters gilenya...	gilenya	2
1	9eba8f80e7e20f3a2f48685530748fbfa95943e4	completely understand want try results reporte...	gilenya	2
2	fe809672251f6bd0d986e00380f48d047c7e7b76	interesting targets s1p 1 5 receptors rather 1...	fingolimod	2
3	bd22104dfa9ec80db4099523e03fae7a52735eb6	interesting grand merci wonder lemtrada ocrevu...	ocrevus	2
4	b227688381f9b25e5b65109dd00f7f895e838249	hi everybody latest mri results brain cervical...	gilenya	1
5	a043780c757966243779bf3c0d11bf6eef721971	give advice lemtrada chose cladribine thought ...	cladribine	2
6	be5a13376933a7f9bbf8e801c31691092f63260a	reply posted jesszidek hi jess sorry read chal...	humira	0
7	08c3c0c702fc97d290204b37798ac62005da5626	well expected neurologist wants start tysabri ...	gilenya	2
8	8fd3d7ad80791c9343e5cf8a83bd1adf6577d516	think fingolimod miserable failure progressive...	fingolimod	1
9	793c5af7cc8332df17eb602247d886fbd1c80f89	thank much learning lot grace mentioned husban...	tagrisso	2

In [12]:

```
data[data.isnull().any(axis=1)]
```

Out[12]:

unique_hash	text	drug	sentiment

no missing value

Test, Train and Cross Validation Split

Splitting data into train, test and cross validation (64:20:16)

In [161]:

```
data_test.drug  = data_test.drug.str.replace('\s+', '_')
```

In [13]:

```
y_true = data['sentiment'].values
data.drug  = data.drug.str.replace('\s+', '_')

# split the data into test and train by maintaining same distribution of output varaibl
e 'y_true' [stratify=y_true]
X_train, test_df, y_train, y_test = train_test_split(data, y_true, stratify=y_true, tes
t_size=0.2)
# split the train data into train and cross validation by maintaining same distribution
of output varaible 'y_train' [stratify=y_train]
train_df, cv_df, y_train, y_cv = train_test_split(X_train, y_train, stratify=y_train, t
est_size=0.2)
```

We split the data into train, test and cross validation data sets, preserving the ratio of class distribution in the original data set

In [14]:

```
print('Number of data points in train data:', train_df.shape[0])
print('Number of data points in test data:', test_df.shape[0])
print('Number of data points in cross validation data:', cv_df.shape[0])
```

```
Number of data points in train data: 3378
Number of data points in test data: 1056
Number of data points in cross validation data: 845
```

In [15]:

```
train_class_distribution = train_df['sentiment'].value_counts()
type(train_class_distribution)
```

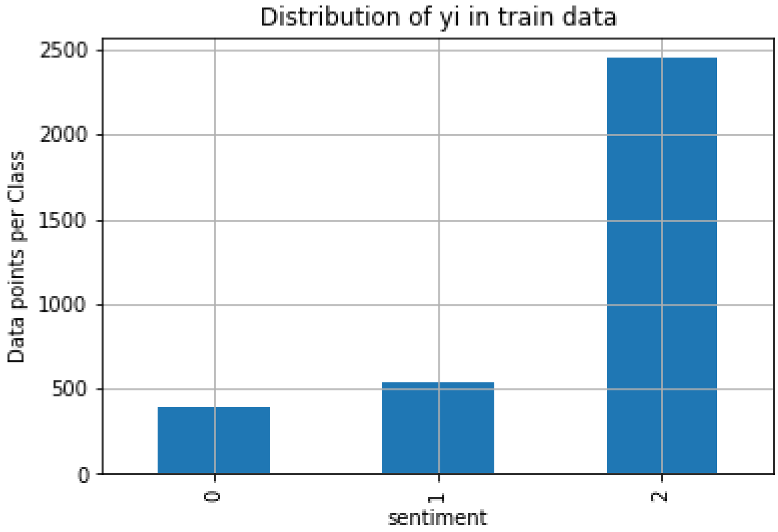
Out[15]:

```
pandas.core.series.Series
```

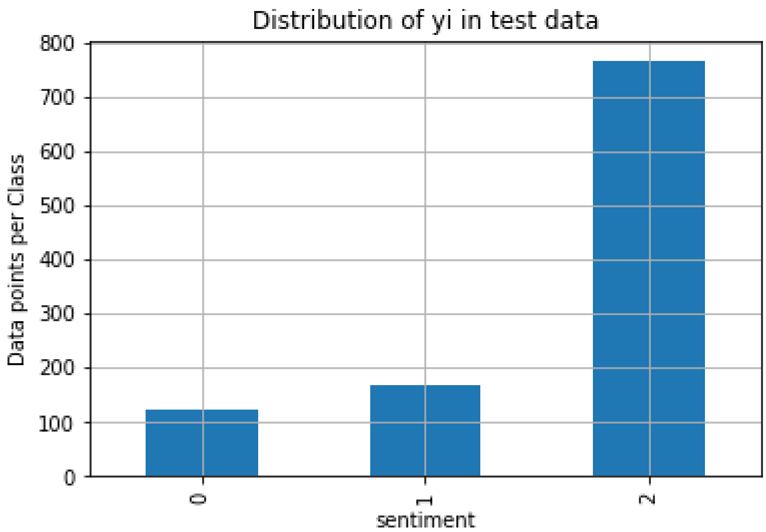
Distribution of y_i's in Train, Test and Cross Validation datasets

In [16]:

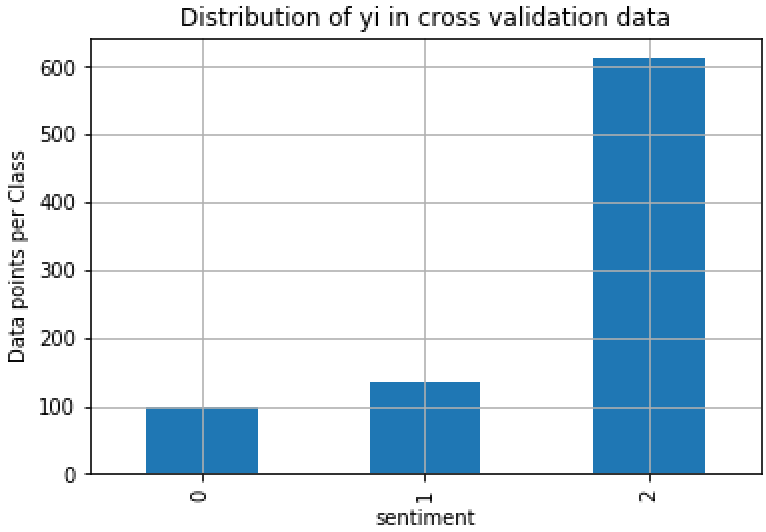
```
#cv_class_distribution = cv_df['Class'].value_counts().sortlevel()
# it returns a dict, keys as class labels and values as the number of data points in th
at class
train_class_distribution = train_df['sentiment'].value_counts().sort_index()
test_class_distribution = test_df['sentiment'].value_counts().sort_index()
cv_class_distribution = cv_df['sentiment'].value_counts().sort_index()

my_colors = 'rgbkymc'
train_class_distribution.plot(kind='bar')
plt.xlabel('sentiment')
plt.ylabel('Data points per Class')
plt.title('Distribution of yi in train data')
plt.grid()
plt.show()

# ref: argsort https://docs.scipy.org/doc/numpy/reference/generated/numpy.argsort.html
# -(train_class_distribution.values): the minus sign will give us in decreasing order
sorted_yi = np.argsort(-train_class_distribution.values)
for i in sorted_yi:
    print('Number of data points in class', i+1, ':',train_class_distribution.values[i
], '(', np.round((train_class_distribution.values[i]/train_df.shape[0]*100), 3), '%)')


print('-'*80)
my_colors = 'rgbkymc'
test_class_distribution.plot(kind='bar')
plt.xlabel('sentiment')
plt.ylabel('Data points per Class')
plt.title('Distribution of yi in test data')
plt.grid()
plt.show()

# ref: argsort https://docs.scipy.org/doc/numpy/reference/generated/numpy.argsort.html
# -(train_class_distribution.values): the minus sign will give us in decreasing order
sorted_yi = np.argsort(-test_class_distribution.values)
for i in sorted_yi:
    print('Number of data points in class', i+1, ':',test_class_distribution.values[i],
'(', np.round((test_class_distribution.values[i]/test_df.shape[0]*100), 3), '%)')

print('-'*80)
my_colors = 'rgbkymc'
cv_class_distribution.plot(kind='bar')
plt.xlabel('sentiment')
plt.ylabel('Data points per Class')
plt.title('Distribution of yi in cross validation data')
plt.grid()
plt.show()

# ref: argsort https://docs.scipy.org/doc/numpy/reference/generated/numpy.argsort.html
# -(train_class_distribution.values): the minus sign will give us in decreasing order
sorted_yi = np.argsort(-train_class_distribution.values)
for i in sorted_yi:
    print('Number of data points in class', i+1, ':',cv_class_distribution.values[i],
'(', np.round((cv_class_distribution.values[i]/cv_df.shape[0]*100), 3), '%)')
```




```
Number of data points in class 3 : 2448 ( 72.469 %)
Number of data points in class 2 : 535 ( 15.838 %)
Number of data points in class 1 : 395 ( 11.693 %)
--------------------------------------------------------------------------
------
```




```
Number of data points in class 3 : 765 ( 72.443 %)
Number of data points in class 2 : 168 ( 15.909 %)
Number of data points in class 1 : 123 ( 11.648 %)
--------------------------------------------------------------------------
------
```




```
Number of data points in class 3 : 612 ( 72.426 %)
Number of data points in class 2 : 134 ( 15.858 %)
Number of data points in class 1 : 99 ( 11.716 %)
```

Data are imbalance

all tran test and cv have almost same distribution(good for model)

In [ ]:

In [18]:

Univariate Analysis

In [26]:

```
Features :  ['unique_hash' 'text' 'drug' 'sentiment']
```

In [61]:

```
# get_gv_fea_dict: Get Gene varaition Feature Dict
def get_gv_fea_dict(alpha, feature, df):


    value_count = train_df[feature].value_counts()

    # gv_dict : Gene Variation Dict, which contains the probability array for each gen
e/variation
    gv_dict = dict()

    # denominator will contain the number of time that particular feature occured in wh
ole data
    for i, denominator in value_count.items():
        # vec will contain (p(yi==1/Gi) probability of gene/variation belongs to pertic
ular class
        # vec is 9 diamensional vector
        vec = []
        for k in range(0,3):
            # print(train_df.loc[(train_df['Class']==1) & (train_df['Gene']=='BRCA1')])
            #         ID   Gene             Variation  Class
            # 2470  2470  BRCA1                S1715C      1
            # 2486  2486  BRCA1                S1841R      1
            # 2614  2614  BRCA1                   M1R      1
            # 2432  2432  BRCA1                L1657P      1
            # 2567  2567  BRCA1                T1685A      1
            # 2583  2583  BRCA1                E1660G      1
            # 2634  2634  BRCA1                W1718L      1
            # cls_cnt.shape[0] will return the number of rows

            cls_cnt = train_df.loc[(train_df['drug']==k) & (train_df[feature]==i)]

            # cls_cnt.shape[0](numerator) will contain the number of time that particul
ar feature occured in whole data
            vec.append((cls_cnt.shape[0] + alpha*30)/ (denominator + 70*alpha))

        # we are adding the gene/variation to the dict as key and vec as value
        gv_dict[i]=vec
    return gv_dict

# Get Gene variation feature
def get_gv_feature(alpha, feature, df):

    gv_dict = get_gv_fea_dict(alpha, feature, df)
    # value_count is similar in get_gv_fea_dict
    value_count = train_df[feature].value_counts()

    # gv_fea: Gene_variation feature, it will contain the feature for each feature valu
e in the data
    gv_fea = []
    # for every feature values in the given data frame we will check if it is there in
 the train data then we will add the feature to gv_fea
    # if not we will add [1/9,1/9,1/9,1/9,1/9,1/9,1/9,1/9,1/9] to gv_fea
    for index, row in df.iterrows():
        if row[feature] in dict(value_count).keys():
            gv_fea.append(gv_dict[row[feature]])
        else:
            gv_fea.append([1/3,1/3,1/3])
#
    return gv_fea
```

In [62]:

```
print('Features : ', data.columns.values)
```

```
Features :  ['unique_hash' 'text' 'drug' 'sentiment']
```

In [63]:

```
unique_drug = train_df['drug'].value_counts()
print('Number of Unique drug :', unique_drug.shape[0])
# the top 10 genes that occured most
print(unique_drug.head(10))
```

```
Number of Unique drug : 89
ocrevus         425
gilenya         420
ocrelizumab     278
humira          180
entyvio         178
fingolimod      157
tarceva         155
remicade        151
opdivo          145
keytruda        133
Name: drug, dtype: int64
```

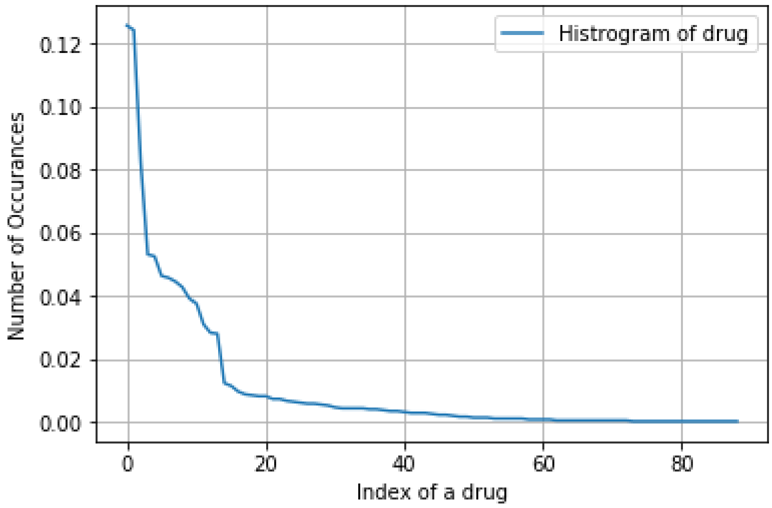
In [64]:

```
print("Ans: There are", unique_drug.shape[0] ,"different categories of drug in the trai
n data, and they are distibuted as follows",)
```

```
Ans: There are 89 different categories of drug in the train data, and they
are distibuted as follows
```

In [65]:

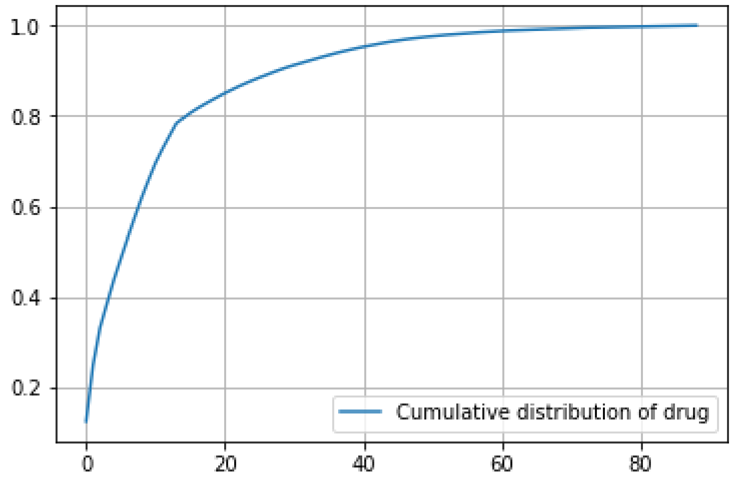
```
s = sum(unique_drug.values);
h = unique_drug.values/s;
plt.plot(h, label="Histrogram of drug")
plt.xlabel('Index of a drug')
plt.ylabel('Number of Occurances')
plt.legend()
plt.grid()
plt.show()
```



most of the drug occure very few time it is right skewed histogram plot very less variation of drug occure maximum times.

In [66]:

```
c = np.cumsum(h)
plt.plot(c,label='Cumulative distribution of drug')
plt.grid()
plt.legend()
plt.show()
```



top 20 drug occupy 82% of data

Featurization

there are two ways we can featurize this variable

One hot Encoding

Response coding

We will choose the appropriate featurization based on the ML model we use. For this problem of multi-class classification with categorical features, one-hot encoding is better for Logistic regression while response coding is better for Random Forests.

In [ ]:

```

```

In [163]:

```
data_test_drug_feature_responseCoding = np.array(get_gv_feature(alpha, "drug", data_tes
t))
```

In [ ]:

```

```

In [160]:

```
#response-coding of the drug feature
# alpha is used for laplace smoothing
alpha = 1
# train gene feature
train_drug_feature_responseCoding = np.array(get_gv_feature(alpha, "drug", train_df))
# test gene feature
test_drug_feature_responseCoding = np.array(get_gv_feature(alpha, "drug", test_df))
# cross validation gene feature
cv_drug_feature_responseCoding = np.array(get_gv_feature(alpha, "drug", cv_df))
```

In [46]:

```
print("train_gene_feature_responseCoding is converted feature using respone coding meth
od. The shape of gene feature:", train_drug_feature_responseCoding.shape)
```

```
train_gene_feature_responseCoding is converted feature using respone codin
g method. The shape of gene feature: (3378, 3)
```

In [47]:

```
# one-hot encoding of drug feature.
drug_vectorizer = CountVectorizer()
train_drug_feature_onehotCoding = drug_vectorizer.fit_transform(train_df['drug'])
test_drug_feature_onehotCoding = drug_vectorizer.transform(test_df['drug'])
cv_drug_feature_onehotCoding = drug_vectorizer.transform(cv_df['drug'])
```

In [191]:

```
data_test_drug_feature_onehotCoding = drug_vectorizer.transform(data_test['drug'])
```

In [48]:

```
train_df['drug'].head()
```

Out[48]:

```
1266    fingolimod
4921       ocrevus
3741       gilenya
4936       tysabri
1489      afatinib
Name: drug, dtype: object
```

In [49]:

```
drug_vectorizer.get_feature_names()
```

Out[49]:

```
['afatinib',
 'aflibercept',
 'alecensa',
 'alectinib',
 'alimta',
 'almita',
 'arzerra',
 'atezolizumab',
 'aubagio',
 'avastin',
 'bevacizumab',
 'brigatinib',
 'brolucizumab',
 'ceritinib',
 'certolizumab_pegol',
 'cimzia',
 'cladribine',
 'crizotinib',
 'ct',
 'cyltezo',
 'cyramza',
 'dabrafenib',
 'dexamethasone',
 'dexamethasone_implant',
 'durvalumab',
 'dyyb',
 'entrectinib',
 'entyvio',
 'erlotinib',
 'eylea',
 'filgotinib',
 'fingolimod',
 'gefitinib',
 'geftinib',
 'gilenya',
 'gilotrif',
 'golimumab',
 'guselkumab',
 'humira',
 'imfinzi',
 'inflectra',
 'infliximab',
 'ipilimumab',
 'iressa',
 'ixifi',
 'keytruda',
 'laser_photocoagulation',
 'lemtrada',
 'lucentis',
 'macugen',
 'mavenclad',
 'mekinist',
 'movectro',
 'necitumumab',
 'nivolumab',
 'ocrelizumab',
 'ocrevus',
 'ofatumumab',
 'opdivo',
```

```
 'osimertinib',
 'ozurdex',
 'p13',
 'pan',
 'panretinal_photocoagulation',
 'pegaptanib',
 'pembrolizumab',
 'pemetrexed',
 'pemrolizumab',
 'photodynamic_therapy',
 'ranibizumab',
 'remicade',
 'remsima',
 'renflexis',
 'retinal_photocoagulation',
 'rhumab_2h7',
 'simponi',
 'siponimod',
 'stelara',
 'tafinlar',
 'tagrisso',
 'tarceva',
 'tecentriq',
 'tofacitinib',
 'trametinib',
 'tysabri',
 'upadacitinib',
 'ustekinumab',
 'vedolizumab',
 'vitrectomy',
 'xalkori',
 'yervoy',
 'zykadia']
```

In [50]:

```
print("train_drug_feature_onehotCoding is converted feature using one-hot encoding meth
od. The shape of gene feature:", train_drug_feature_onehotCoding.shape)
```

```
train_gene_feature_onehotCoding is converted feature using one-hot encodin
g method. The shape of gene feature: (3378, 92)
```

In [51]:

```
print("Q6. How many data points in Test and CV datasets are covered by the ", unique_dr
ug.shape[0], " drugs in train dataset?")

test_coverage=test_df[test_df['drug'].isin(list(set(train_df['drug'])))].shape[0]
cv_coverage=cv_df[cv_df['drug'].isin(list(set(train_df['drug'])))].shape[0]

print('Ans\n1. In test data',test_coverage, 'out of',test_df.shape[0], ":",(test_covera
ge/test_df.shape[0])*100)
print('2. In cross validation data',cv_coverage, 'out of ',cv_df.shape[0],":" ,(cv_cove
rage/cv_df.shape[0])*100)
```

```
Q6. How many data points in Test and CV datasets are covered by the  89  d
rugs in train dataset?
Ans
1. In test data 1047 out of 1056 : 99.14772727272727
2. In cross validation data 838 out of  845 : 99.1715976331361
```

In [ ]:

```

```

Univariate Analysis on Text Feature

In [52]:

```
# cls_text is a data frame
# for every row in data fram consider the 'TEXT'
# split the words by space
# make a dict with those words
# increment its count whenever we see that word

def extract_dictionary_paddle(cls_text):
    dictionary = defaultdict(int)
    for index, row in cls_text.iterrows():
        for word in row['text'].split():
            dictionary[word] +=1
    return dictionary
```

In [111]:

```
import math
#https://stackoverflow.com/a/1602964
def get_text_responsecoding(df):
    text_feature_responseCoding = np.zeros((df.shape[0],3))
    for i in range(0,3):
        row_index = 0
        for index, row in df.iterrows():
            sum_prob = 0
            for word in row['text'].split():
                sum_prob += math.log(((dict_list[i].get(word,0)+30 )/(total_dict.get(wo
rd,0)+70)))
            text_feature_responseCoding[row_index][i] = math.exp(sum_prob/len(row['tex
t'].split()))
            row_index += 1
    return text_feature_responseCoding
```

In [68]:

```
# building a CountVectorizer with all the words that occured minimum 3 times in train d
ata
text_vectorizer = CountVectorizer(min_df=3)
train_text_feature_onehotCoding = text_vectorizer.fit_transform(train_df['text'])
# getting all the feature names (words)
train_text_features= text_vectorizer.get_feature_names()

# train_text_feature_onehotCoding.sum(axis=0).A1 will sum every row and returns (1*numb
er of features) vector
train_text_fea_counts = train_text_feature_onehotCoding.sum(axis=0).A1

# zip(list(text_features),text_fea_counts) will zip a word with its number of times it
 occured
text_fea_dict = dict(zip(list(train_text_features),train_text_fea_counts))


print("Total number of unique words in train data :", len(train_text_features))
```

```
Total number of unique words in train data : 13117
```

In [69]:

```
dict_list = []
# dict_list =[] contains 9 dictoinaries each corresponds to a class
for i in range(0,3):
    cls_text = train_df[train_df['sentiment']==i]
    # build a word dict based on the words in that class
    dict_list.append(extract_dictionary_paddle(cls_text))
    # append it to dict_list

# dict_list[i] is build on i'th  class text data
# total_dict is buid on whole training text data
total_dict = extract_dictionary_paddle(train_df)


confuse_array = []
for i in train_text_features:
    ratios = []
    max_val = -1
    for j in range(0,3):
        ratios.append((dict_list[j][i]+10 )/(total_dict[i]+90))
    confuse_array.append(ratios)
confuse_array = np.array(confuse_array)
```

In [ ]:

In [158]:

```
data_test_text_feature_responseCoding  = get_text_responsecoding(data_test)
```

In [ ]:

In [112]:

```
#response coding of text features
train_text_feature_responseCoding  = get_text_responsecoding(train_df)
test_text_feature_responseCoding  = get_text_responsecoding(test_df)
cv_text_feature_responseCoding  = get_text_responsecoding(cv_df)
```

In [71]:

```
# don't forget to normalize every feature
train_text_feature_onehotCoding = normalize(train_text_feature_onehotCoding, axis=0)

# we use the same vectorizer that was trained on train data
test_text_feature_onehotCoding = text_vectorizer.transform(test_df['text'])
# don't forget to normalize every feature
test_text_feature_onehotCoding = normalize(test_text_feature_onehotCoding, axis=0)

# we use the same vectorizer that was trained on train data
cv_text_feature_onehotCoding = text_vectorizer.transform(cv_df['text'])
# don't forget to normalize every feature
cv_text_feature_onehotCoding = normalize(cv_text_feature_onehotCoding, axis=0)
```

In [ ]:

```

```

In [192]:

```
# we use the same vectorizer that was trained on train data
data_test_text_feature_onehotCoding = text_vectorizer.transform(data_test['text'])
# don't forget to normalize every feature
data_test_text_feature_onehotCoding = normalize(data_test_text_feature_onehotCoding, ax
is=0)
```

In [ ]:

```

```

In [72]:

```
#https://stackoverflow.com/a/2258273/4084039
sorted_text_fea_dict = dict(sorted(text_fea_dict.items(), key=lambda x: x[1] , reverse=
True))
sorted_text_occur = np.array(list(sorted_text_fea_dict.values()))
```

In [73]:

```
# Number of words for a given frequency.
print(Counter(sorted_text_occur))
```

```
Counter({3: 1552, 4: 1184, 5: 898, 6: 799, 7: 639, 8: 544, 9: 473, 10: 37
9, 11: 354, 13: 306, 12: 302, 14: 264, 16: 211, 15: 198, 17: 168, 18: 163,
19: 152, 21: 149, 20: 144, 22: 122, 23: 117, 24: 109, 25: 102, 27: 85, 30:
82, 29: 78, 28: 78, 31: 77, 32: 72, 33: 69, 26: 68, 35: 66, 43: 61, 34: 5
9, 38: 56, 39: 53, 37: 51, 40: 49, 36: 48, 42: 46, 44: 45, 41: 43, 46: 42,
59: 40, 45: 40, 63: 37, 67: 34, 52: 33, 50: 33, 49: 33, 55: 32, 47: 31, 6
2: 30, 53: 30, 60: 29, 56: 29, 51: 29, 58: 28, 54: 28, 80: 26, 70: 26, 64:
26, 48: 26, 57: 25, 81: 24, 77: 24, 69: 24, 61: 24, 74: 23, 72: 23, 85: 2
1, 73: 21, 113: 20, 101: 20, 78: 20, 66: 20, 99: 18, 95: 18, 76: 18, 75: 1
8, 71: 18, 94: 17, 68: 17, 93: 16, 87: 16, 79: 16, 102: 15, 89: 15, 65: 1
5, 115: 14, 112: 14, 103: 14, 97: 14, 92: 14, 90: 14, 84: 14, 83: 14, 129:
13, 108: 13, 98: 13, 88: 13, 134: 12, 124: 12, 119: 12, 118: 12, 104: 12,
135: 11, 105: 11, 150: 10, 137: 10, 100: 10, 91: 10, 86: 10, 218: 9, 149:
9, 144: 9, 121: 9, 117: 9, 82: 9, 167: 8, 142: 8, 139: 8, 138: 8, 136: 8,
116: 8, 107: 8, 207: 7, 204: 7, 192: 7, 166: 7, 158: 7, 155: 7, 147: 7, 12
8: 7, 96: 7, 286: 6, 281: 6, 278: 6, 244: 6, 205: 6, 201: 6, 197: 6, 191:
6, 179: 6, 169: 6, 168: 6, 157: 6, 146: 6, 127: 6, 126: 6, 123: 6, 122: 6,
110: 6, 296: 5, 292: 5, 261: 5, 235: 5, 220: 5, 216: 5, 212: 5, 211: 5, 20
9: 5, 206: 5, 202: 5, 194: 5, 193: 5, 183: 5, 181: 5, 178: 5, 175: 5, 154:
5, 148: 5, 141: 5, 132: 5, 109: 5, 420: 4, 370: 4, 355: 4, 316: 4, 305: 4,
270: 4, 268: 4, 263: 4, 260: 4, 257: 4, 252: 4, 242: 4, 233: 4, 232: 4, 22
6: 4, 219: 4, 200: 4, 198: 4, 195: 4, 190: 4, 187: 4, 186: 4, 177: 4, 176:
4, 171: 4, 170: 4, 165: 4, 164: 4, 159: 4, 151: 4, 145: 4, 143: 4, 140: 4,
131: 4, 130: 4, 125: 4, 120: 4, 111: 4, 106: 4, 510: 3, 496: 3, 491: 3, 46
6: 3, 464: 3, 441: 3, 424: 3, 414: 3, 392: 3, 390: 3, 379: 3, 359: 3, 358:
3, 353: 3, 351: 3, 323: 3, 319: 3, 318: 3, 315: 3, 307: 3, 300: 3, 299: 3,
298: 3, 297: 3, 276: 3, 274: 3, 273: 3, 258: 3, 246: 3, 240: 3, 239: 3, 23
8: 3, 237: 3, 234: 3, 231: 3, 230: 3, 227: 3, 225: 3, 221: 3, 213: 3, 199:
3, 196: 3, 188: 3, 185: 3, 184: 3, 180: 3, 163: 3, 156: 3, 153: 3, 152: 3,
133: 3, 114: 3, 994: 2, 942: 2, 797: 2, 774: 2, 738: 2, 683: 2, 659: 2, 62
6: 2, 581: 2, 568: 2, 551: 2, 547: 2, 543: 2, 542: 2, 530: 2, 522: 2, 503:
2, 500: 2, 483: 2, 467: 2, 455: 2, 452: 2, 436: 2, 434: 2, 433: 2, 419: 2,
415: 2, 408: 2, 405: 2, 404: 2, 402: 2, 401: 2, 397: 2, 396: 2, 395: 2, 39
1: 2, 389: 2, 387: 2, 384: 2, 362: 2, 357: 2, 356: 2, 354: 2, 348: 2, 344:
2, 342: 2, 335: 2, 334: 2, 332: 2, 331: 2, 330: 2, 317: 2, 311: 2, 306: 2,
303: 2, 302: 2, 295: 2, 290: 2, 289: 2, 288: 2, 275: 2, 272: 2, 267: 2, 26
6: 2, 259: 2, 256: 2, 255: 2, 253: 2, 251: 2, 250: 2, 243: 2, 236: 2, 229:
2, 228: 2, 224: 2, 223: 2, 222: 2, 217: 2, 210: 2, 208: 2, 189: 2, 182: 2,
173: 2, 161: 2, 6025: 1, 5066: 1, 4638: 1, 3684: 1, 3619: 1, 3032: 1, 272
2: 1, 2431: 1, 2258: 1, 2149: 1, 2148: 1, 2119: 1, 2107: 1, 2001: 1, 1934:
1, 1878: 1, 1876: 1, 1834: 1, 1826: 1, 1806: 1, 1768: 1, 1742: 1, 1701: 1,
1665: 1, 1657: 1, 1611: 1, 1597: 1, 1564: 1, 1561: 1, 1490: 1, 1396: 1, 13
70: 1, 1347: 1, 1343: 1, 1336: 1, 1321: 1, 1292: 1, 1279: 1, 1252: 1, 124
0: 1, 1236: 1, 1226: 1, 1200: 1, 1184: 1, 1171: 1, 1166: 1, 1157: 1, 1145:
1, 1139: 1, 1138: 1, 1129: 1, 1116: 1, 1108: 1, 1106: 1, 1101: 1, 1088: 1,
1081: 1, 1075: 1, 1069: 1, 1059: 1, 1056: 1, 1046: 1, 1035: 1, 1028: 1, 10
22: 1, 1018: 1, 1003: 1, 989: 1, 987: 1, 978: 1, 970: 1, 968: 1, 966: 1, 9
52: 1, 944: 1, 935: 1, 932: 1, 931: 1, 918: 1, 912: 1, 897: 1, 884: 1, 88
1: 1, 879: 1, 869: 1, 855: 1, 848: 1, 846: 1, 839: 1, 838: 1, 836: 1, 831:
1, 829: 1, 828: 1, 819: 1, 816: 1, 813: 1, 812: 1, 811: 1, 810: 1, 809: 1,
805: 1, 800: 1, 791: 1, 785: 1, 780: 1, 775: 1, 770: 1, 768: 1, 763: 1, 75
2: 1, 749: 1, 745: 1, 742: 1, 735: 1, 731: 1, 726: 1, 715: 1, 710: 1, 708:
1, 704: 1, 697: 1, 694: 1, 692: 1, 691: 1, 690: 1, 689: 1, 677: 1, 676: 1,
675: 1, 674: 1, 671: 1, 658: 1, 652: 1, 650: 1, 645: 1, 644: 1, 640: 1, 63
9: 1, 637: 1, 622: 1, 612: 1, 611: 1, 605: 1, 593: 1, 591: 1, 587: 1, 586:
1, 584: 1, 580: 1, 579: 1, 576: 1, 574: 1, 573: 1, 565: 1, 560: 1, 554: 1,
546: 1, 544: 1, 537: 1, 536: 1, 535: 1, 532: 1, 528: 1, 523: 1, 521: 1, 51
8: 1, 517: 1, 516: 1, 512: 1, 511: 1, 509: 1, 508: 1, 504: 1, 501: 1, 498:
1, 495: 1, 490: 1, 488: 1, 487: 1, 482: 1, 480: 1, 477: 1, 476: 1, 470: 1,
468: 1, 460: 1, 459: 1, 458: 1, 454: 1, 450: 1, 449: 1, 448: 1, 446: 1, 44
2: 1, 440: 1, 439: 1, 437: 1, 435: 1, 432: 1, 431: 1, 430: 1, 428: 1, 426:
```

```
1, 423: 1, 418: 1, 413: 1, 411: 1, 407: 1, 406: 1, 400: 1, 394: 1, 393: 1,
386: 1, 383: 1, 382: 1, 381: 1, 374: 1, 373: 1, 369: 1, 368: 1, 367: 1, 36
6: 1, 364: 1, 363: 1, 349: 1, 346: 1, 345: 1, 340: 1, 339: 1, 338: 1, 337:
1, 333: 1, 328: 1, 327: 1, 326: 1, 325: 1, 324: 1, 322: 1, 313: 1, 312: 1,
310: 1, 309: 1, 304: 1, 301: 1, 294: 1, 293: 1, 291: 1, 287: 1, 285: 1, 28
3: 1, 282: 1, 279: 1, 271: 1, 265: 1, 264: 1, 262: 1, 254: 1, 249: 1, 248:
1, 247: 1, 215: 1, 214: 1, 203: 1, 172: 1, 162: 1, 160: 1})
```

In [74]:

```
def get_intersec_text(df):
    df_text_vec = CountVectorizer(min_df=3)
    df_text_fea = df_text_vec.fit_transform(df['text'])
    df_text_features = df_text_vec.get_feature_names()

    df_text_fea_counts = df_text_fea.sum(axis=0).A1
    df_text_fea_dict = dict(zip(list(df_text_features),df_text_fea_counts))
    len1 = len(set(df_text_features))
    len2 = len(set(train_text_features) & set(df_text_features))
    return len1,len2
```

In [75]:

```
len1,len2 = get_intersec_text(test_df)
print(np.round((len2/len1)*100, 3), "% of word of test data appeared in train data")
len1,len2 = get_intersec_text(cv_df)
print(np.round((len2/len1)*100, 3), "% of word of Cross Validation appeared in train da
ta")
```

```
97.158 % of word of test data appeared in train data
98.139 % of word of Cross Validation appeared in train data
```

In [ ]:

```

```

Machine Learning Models

In [101]:

```
#Data preparation for ML models.

#Misc. functionns for ML models


def predict_and_plot_confusion_matrix(train_x, train_y,test_x, test_y, clf):
    clf.fit(train_x, train_y)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(train_x, train_y)
    pred_y = sig_clf.predict(test_x)

    # for calculating f1_score we willl provide the array of probabilities belongs to e
ach class
    print("f1 score :",f1_score(test_y, sig_clf.predict(test_x),average='macro'))
    # calculating the number of data points that are misclassified
    print("Number of mis-classified points :", np.count_nonzero((pred_y- test_y))/test_
y.shape[0])
    plot_confusion_matrix(test_y, pred_y)
```

In [102]:

```
def report_f1_score(train_x, train_y, test_x, test_y,  clf):
    clf.fit(train_x, train_y)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(train_x, train_y)
    sig_clf_probs = sig_clf.predict(test_x)
    return f1_score(test_y, sig_clf_probs,average='macro')
```

In [103]:

```
# this function will be used just for naive bayes
# for the given indices, we will print the name of the features
# and we will check whether the feature present in the test point text or not
def get_impfeature_names(indices, text, drug, var, no_features):
    drug_count_vec = CountVectorizer()
    text_count_vec = CountVectorizer(min_df=3)

    drug_vec = drug_count_vec.fit(train_df['drug'])
    text_vec = text_count_vec.fit(train_df['text'])

    fea1_len = len(drug_vec.get_feature_names())

    word_present = 0
    for i,v in enumerate(indices):
        if (v < fea1_len):
            word = drug_vec.get_feature_names()[v]
            yes_no = True if word == drug else False
            if yes_no:
                word_present += 1
                print(i, "drug feature [{}] present in test data point [{}]".format(wor
d,yes_no))
        else:
            word = text_vec.get_feature_names()[v-(fea1_len)]
            yes_no = True if word in text.split() else False
            if yes_no:
                word_present += 1
                print(i, "Text feature [{}] present in test data point [{}]".format(wor
d,yes_no))

    print("Out of the top ",no_features," features ", word_present, "are present in que
ry point")
```

Stacking the feature

In [113]:

```
'''
train_drug_var_onehotCoding = hstack((train_drug_feature_onehotCoding,train_variation_f
eature_onehotCoding))
test_drug_var_onehotCoding = hstack((test_drug_feature_onehotCoding,test_variation_feat
ure_onehotCoding))
cv_drug_var_onehotCoding = hstack((cv_drug_feature_onehotCoding,cv_variation_feature_on
ehotCoding))'''

train_x_onehotCoding = hstack((train_drug_feature_onehotCoding, train_text_feature_oneh
otCoding)).tocsr()
train_y = np.array(list(train_df['sentiment']))

test_x_onehotCoding = hstack((test_drug_feature_onehotCoding, test_text_feature_onehotC
oding)).tocsr()
test_y = np.array(list(test_df['sentiment']))

cv_x_onehotCoding = hstack((cv_drug_feature_onehotCoding, cv_text_feature_onehotCoding
)).tocsr()
cv_y = np.array(list(cv_df['sentiment']))


'''train_drug_var_responseCoding = np.hstack((train_drug_feature_responseCoding,train_v
ariation_feature_responseCoding))
test_drug_var_responseCoding = np.hstack((test_drug_feature_responseCoding,test_variati
on_feature_responseCoding))
cv_drug_var_responseCoding = np.hstack((cv_drug_feature_responseCoding,cv_variation_fea
ture_responseCoding))'''

train_x_responseCoding = np.hstack((train_drug_feature_responseCoding, train_text_featu
re_responseCoding))
test_x_responseCoding = np.hstack((test_drug_feature_responseCoding, test_text_feature_
responseCoding))
cv_x_responseCoding = np.hstack((cv_drug_feature_responseCoding, cv_text_feature_respon
seCoding))
```

In [ ]:

In [193]:

```
data_test_x_onehotCoding = hstack((data_test_drug_feature_onehotCoding, data_test_text_
feature_onehotCoding)).tocsr()
```

In [164]:

```
data_test_x_responseCoding = np.hstack((data_test_drug_feature_responseCoding, data_tes
t_text_feature_responseCoding))
```

In [ ]:

In [ ]:

In [82]:

```
print("One hot encoding features :")
print("(number of data points * number of features) in train data = ", train_x_onehotCo
ding.shape)
print("(number of data points * number of features) in test data = ", test_x_onehotCodi
ng.shape)
print("(number of data points * number of features) in cross validation data =", cv_x_o
nehotCoding.shape)
```

```
One hot encoding features :
(number of data points * number of features) in train data =  (3378, 1320
9)
(number of data points * number of features) in test data =  (1056, 13209)
(number of data points * number of features) in cross validation data = (8
45, 13209)
```

In [114]:

```
print(" Response encoding features :")
print("(number of data points * number of features) in train data = ", train_x_response
Coding.shape)
print("(number of data points * number of features) in test data = ", test_x_responseCo
ding.shape)
print("(number of data points * number of features) in cross validation data =", cv_x_r
esponseCoding.shape)
```

```
 Response encoding features :
(number of data points * number of features) in train data =  (3378, 6)
(number of data points * number of features) in test data =  (1056, 6)
(number of data points * number of features) in cross validation data = (8
45, 6)
```

Naive Bayes

In [104]:

```
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))

    labels = [0,1,2]
    # representing A in heatmap format
    print("-"*20, "Confusion matrix", "-"*20)
    plt.figure(figsize=(20,7))
    sns.heatmap(C, annot=True, cmap="YlGnBu", fmt=".3f", xticklabels=labels, yticklabel
s=labels)
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.show()

    print("-"*20, "Precision matrix (Columm Sum=1)", "-"*20)
    plt.figure(figsize=(20,7))
    sns.heatmap(B, annot=True, cmap="YlGnBu", fmt=".3f", xticklabels=labels, yticklabel
s=labels)
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.show()

    # representing B in heatmap format
    print("-"*20, "Recall matrix (Row sum=1)", "-"*20)
    plt.figure(figsize=(20,7))
    sns.heatmap(A, annot=True, cmap="YlGnBu", fmt=".3f", xticklabels=labels, yticklabel
s=labels)
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.show()
```

Hyper parameter tuning

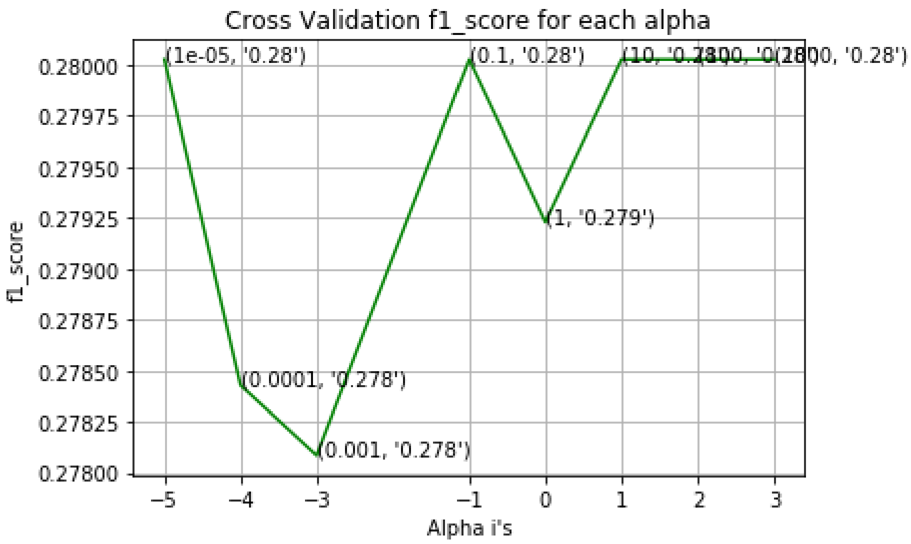
In [ ]:

```
from sklearn.metrics import f1_score
```

In [105]:

```
# find more about Multinomial Naive base function here http://scikit-learn.org/stable/m
odules/generated/sklearn.naive_bayes.MultinomialNB.html
alpha = [0.00001, 0.0001, 0.001, 0.1, 1, 10, 100,1000]
cv_f1_score_array = []
for i in alpha:
    print("for alpha =", i)
    clf = MultinomialNB(alpha=i)
    clf.fit(train_x_onehotCoding, train_y)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(train_x_onehotCoding, train_y)
    sig_clf_probs = sig_clf.predict(cv_x_onehotCoding)
    cv_f1_score_array.append(f1_score(cv_y, sig_clf_probs,average='macro'))
    # to avoid rounding error while multiplying probabilites we use log-probability est
imates
    print("f1_score :",f1_score(cv_y, sig_clf_probs,average='macro'))

fig, ax = plt.subplots()
ax.plot(np.log10(alpha), cv_f1_score_array,c='g')
for i, txt in enumerate(np.round(cv_f1_score_array,3)):
    ax.annotate((alpha[i],str(txt)), (np.log10(alpha[i]),cv_f1_score_array[i]))
plt.grid()
plt.xticks(np.log10(alpha))
plt.title("Cross Validation f1_score for each alpha")
plt.xlabel("Alpha i's")
plt.ylabel("f1_score")
plt.show()


best_alpha = np.argmax(cv_f1_score_array)
clf = MultinomialNB(alpha=alpha[best_alpha])
clf.fit(train_x_onehotCoding, train_y)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(train_x_onehotCoding, train_y)


predict_y = sig_clf.predict(train_x_onehotCoding)
print('For values of best alpha = ', alpha[best_alpha], "The train f1_score is:",f1_sco
re(y_train, predict_y, labels=clf.classes_,average='macro'))
predict_y = sig_clf.predict(cv_x_onehotCoding)
print('For values of best alpha = ', alpha[best_alpha], "The cross validation f1_score
 is:",f1_score(y_cv, predict_y, labels=clf.classes_,average='macro'))
predict_y = sig_clf.predict(test_x_onehotCoding)
print('For values of best alpha = ', alpha[best_alpha], "The test f1_score is:",f1_scor
e(y_test, predict_y, labels=clf.classes_,average='macro'))
```

```
for alpha = 1e-05
f1_score : 0.2800274536719286
for alpha = 0.0001
f1_score : 0.27842866988283943
for alpha = 0.001
f1_score : 0.2780847145488029
for alpha = 0.1
f1_score : 0.2800274536719286
for alpha = 1
f1_score : 0.27922971114167816
for alpha = 10
f1_score : 0.2800274536719286
for alpha = 100
f1_score : 0.2800274536719286
for alpha = 1000
f1_score : 0.2800274536719286
```



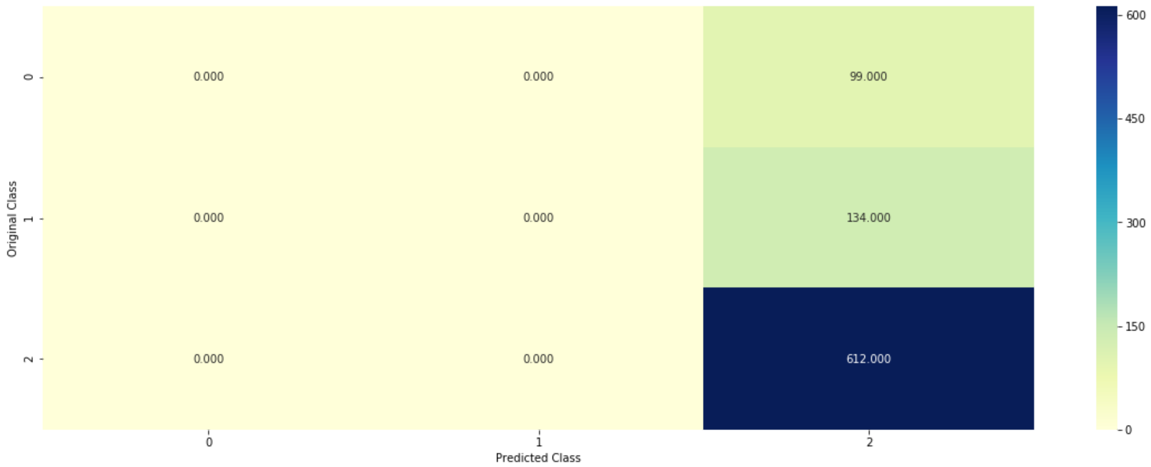

```
For values of best alpha =  1e-05 The train f1_score is: 0.280123583934088
6
For values of best alpha =  1e-05 The cross validation f1_score is: 0.2800
274536719286
For values of best alpha =  1e-05 The test f1_score is: 0.2800658978583196
```

Testing the model with best hyper paramters

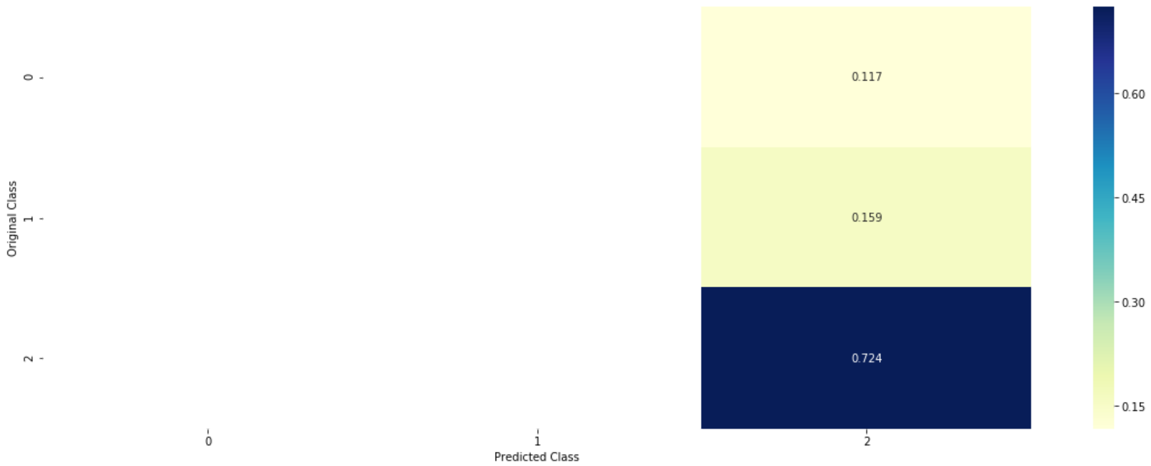
In [106]:

```
clf = MultinomialNB(alpha=alpha[best_alpha])
clf.fit(train_x_onehotCoding, train_y)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(train_x_onehotCoding, train_y)
sig_clf_probs = sig_clf.predict(cv_x_onehotCoding)
# to avoid rounding error while multiplying probabilites we use log-probability estimat
es
print("f1_score :",f1_score(cv_y, sig_clf_probs,average='macro'))
print("Number of missclassified point :", np.count_nonzero((sig_clf.predict(cv_x_onehot
Coding)- cv_y))/cv_y.shape[0])
plot_confusion_matrix(cv_y, sig_clf.predict(cv_x_onehotCoding.toarray()))
```

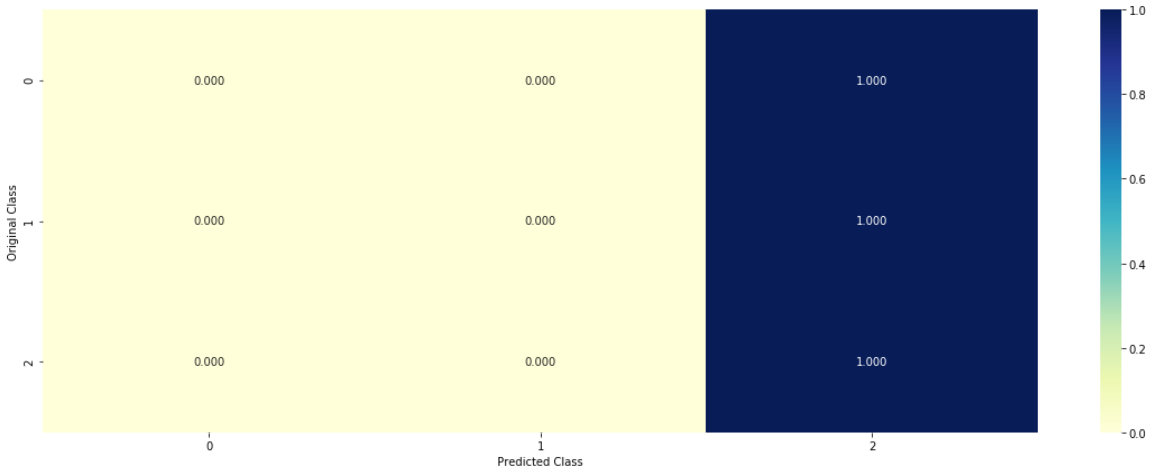
```
f1_score : 0.2800274536719286
Number of missclassified point : 0.2757396449704142
-------------------- Confusion matrix --------------------
```




```
-------------------- Precision matrix (Columm Sum=1) --------------------
```




```
-------------------- Recall matrix (Row sum=1) --------------------
```



Correctly classified point

In [108]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
test_point_index = 1
no_feature = 100
predicted_cls = sig_clf.predict(test_x_onehotCoding[test_point_index])
print("Predicted Class :", predicted_cls[0])
print("Predicted Class Probabilities:", np.round(sig_clf.predict_proba(test_x_onehotCod
ing[test_point_index]),4))
print("Actual Class :", test_y[test_point_index])
indices = np.argsort(-clf.coef_)[predicted_cls-1][:,:no_feature]
print("-"*50)
#get_impfeature_names(indices[0], test_df['text'].iloc[test_point_index],test_df['dru
g'].iloc[test_point_index], no_feature)
```

```
Predicted Class : 2
Predicted Class Probabilities: [[0.1123 0.1361 0.7516]]
Actual Class : 1
--------------------------------------------------
```

In [ ]:

```

```

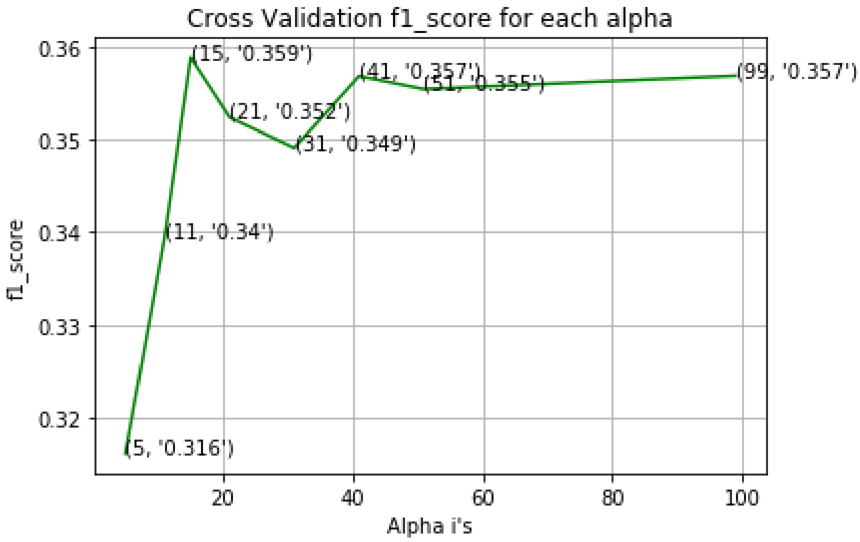
K Nearest Neighbour Classification

Hyper parameter tuning

In [116]:

```
alpha = [5, 11, 15, 21, 31, 41, 51, 99]
cv_f1_score_array = []
for i in alpha:
    print("for alpha =", i)
    clf = KNeighborsClassifier(n_neighbors=i)
    clf.fit(train_x_responseCoding, train_y)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(train_x_responseCoding, train_y)
    sig_clf_probs = sig_clf.predict(cv_x_responseCoding)
    cv_f1_score_array.append(f1_score(cv_y, sig_clf_probs,average='macro'))
    # to avoid rounding error while multiplying probabilites we use log-probability est
imates
    print("f1_score :",f1_score(cv_y, sig_clf_probs,average='macro'))

fig, ax = plt.subplots()
ax.plot(alpha, cv_f1_score_array,c='g')
for i, txt in enumerate(np.round(cv_f1_score_array,3)):
    ax.annotate((alpha[i],str(txt)), (alpha[i],cv_f1_score_array[i]))
plt.grid()
plt.title("Cross Validation f1_score for each alpha")
plt.xlabel("Alpha i's")
plt.ylabel("f1_score")
plt.show()


best_alpha = np.argmax(cv_f1_score_array)
clf = KNeighborsClassifier(n_neighbors=alpha[best_alpha])
clf.fit(train_x_responseCoding, train_y)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(train_x_responseCoding, train_y)

predict_y = sig_clf.predict(train_x_responseCoding)
print('For values of best alpha = ', alpha[best_alpha], "The train f1_score is:",f1_sco
re(y_train, predict_y,average='macro'))
predict_y = sig_clf.predict(cv_x_responseCoding)
print('For values of best alpha = ', alpha[best_alpha], "The cross validation f1_score
 is:",f1_score(y_cv, predict_y,average='macro'))
predict_y = sig_clf.predict(test_x_responseCoding)
print('For values of best alpha = ', alpha[best_alpha], "The test f1_score is:",f1_scor
e(y_test, predict_y,average='macro'))
```

```
for alpha = 5
f1_score : 0.31613435929868944
for alpha = 11
f1_score : 0.3395131681572732
for alpha = 15
f1_score : 0.3587975781020494
for alpha = 21
f1_score : 0.35236370317872795
for alpha = 31
f1_score : 0.3490567788141681
for alpha = 41
f1_score : 0.3567769741666271
for alpha = 51
f1_score : 0.355380683346785
for alpha = 99
f1_score : 0.35680800932682194
```



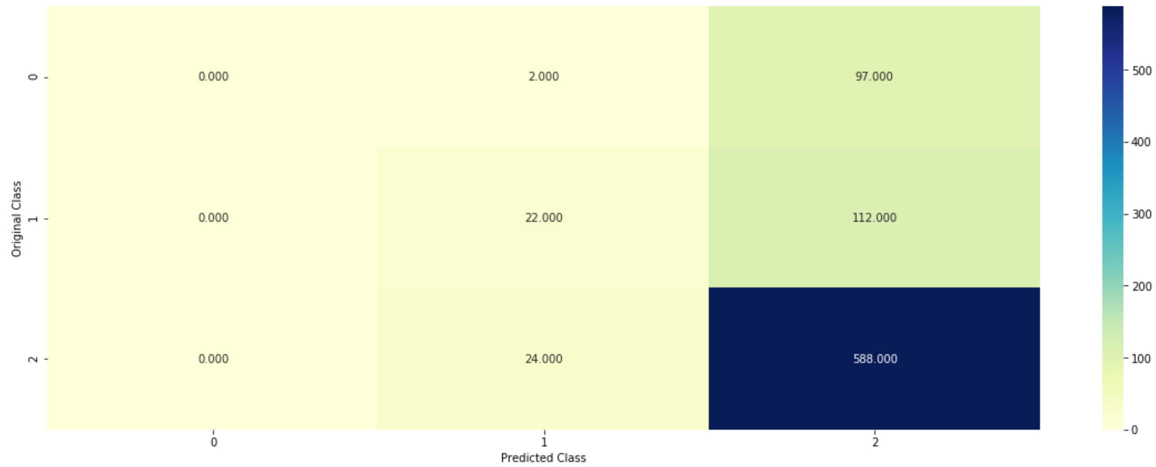

```
For values of best alpha =  15 The train f1_score is: 0.3946232496345659
For values of best alpha =  15 The cross validation f1_score is: 0.3587975
781020494
For values of best alpha =  15 The test f1_score is: 0.33840919578228207
```

Testing the model with best hyper paramters

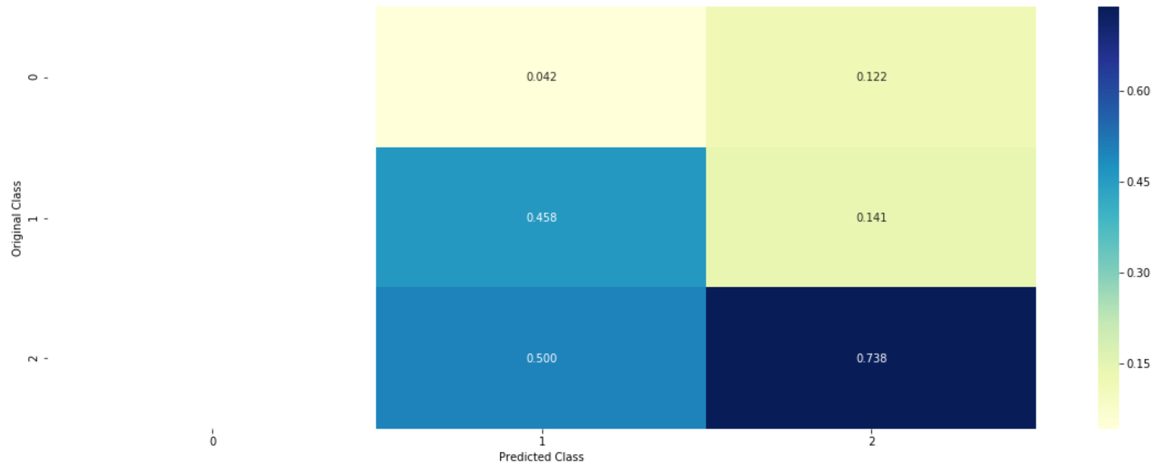
In [117]:

```
# find more about KNeighborsClassifier() here http://scikit-learn.org/stable/modules/ge
nerated/sklearn.neighbors.KNeighborsClassifier.html
# -------------------------
# default parameter
# KNeighborsClassifier(n_neighbors=5, weights='uniform', algorithm='auto', leaf_size=3
0, p=2,
# metric='minkowski', metric_params=None, n_jobs=1, **kwargs)

# methods of
# fit(X, y) : Fit the model using X as training data and y as target values
# predict(X):Predict the class labels for the provided data
# predict_proba(X):Return probability estimates for the test data X.
#-------------------------------------
# video link: https://www.appliedaicourse.com/course/applied-ai-course-online/lessons/k
-nearest-neighbors-geometric-intuition-with-a-toy-example-1/
#-------------------------------------
clf = KNeighborsClassifier(n_neighbors=alpha[best_alpha])
predict_and_plot_confusion_matrix(train_x_responseCoding, train_y, cv_x_responseCoding,
cv_y, clf)
```

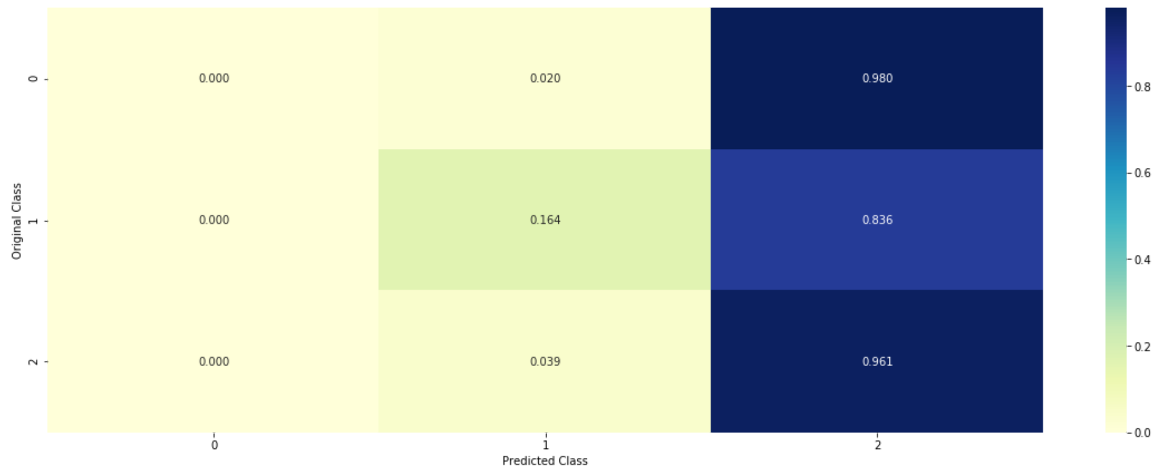
```
f1 score : 0.3587975781020494
Number of mis-classified points : 0.2781065088757396
-------------------- Confusion matrix --------------------
```




```
-------------------- Precision matrix (Columm Sum=1) --------------------
```




```
-------------------- Recall matrix (Row sum=1) --------------------
```



In [118]:

```
clf = KNeighborsClassifier(n_neighbors=alpha[best_alpha])
clf.fit(train_x_responseCoding, train_y)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(train_x_responseCoding, train_y)

test_point_index = 1
predicted_cls = sig_clf.predict(test_x_responseCoding[0].reshape(1,-1))
print("Predicted Class :", predicted_cls[0])
print("Actual Class :", test_y[test_point_index])
neighbors = clf.kneighbors(test_x_responseCoding[test_point_index].reshape(1, -1), alph
a[best_alpha])
print("The ",alpha[best_alpha]," nearest neighbours of the test points belongs to class
es",train_y[neighbors[1][0]])
print("Fequency of nearest points :",Counter(train_y[neighbors[1][0]]))
```

```
Predicted Class : 2
Actual Class : 1
The  15  nearest neighbours of the test points belongs to classes [2 0 2 2
2 2 2 2 2 2 2 2 2 2 2]
Fequency of nearest points : Counter({2: 14, 0: 1})
```

Logistic Regression With Class balancing

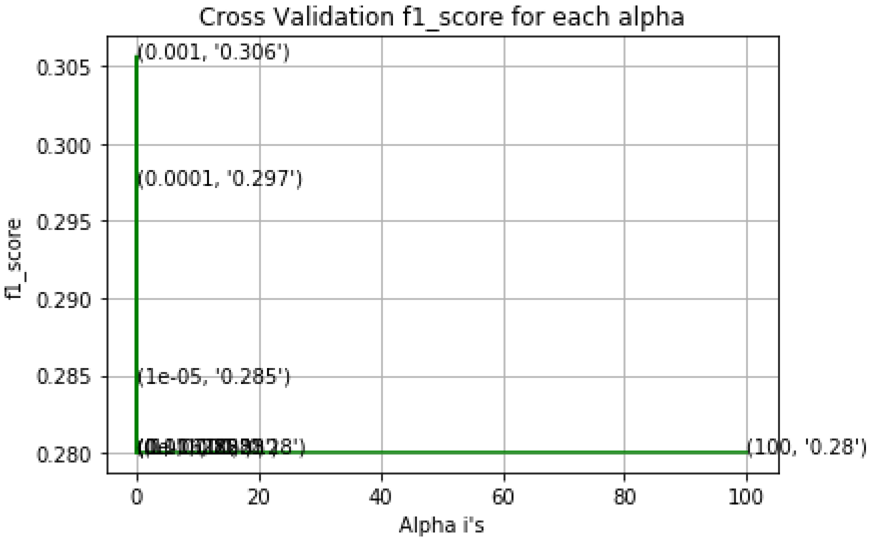
one hot encoding

Hyper paramter tuning

In [138]:

```
alpha = [10 ** x for x in range(-6, 3)]
cv_f1_score_array = []
for i in alpha:
    print("for alpha =", i)
    clf = SGDClassifier(class_weight='balanced', alpha=i, penalty='l2', loss='log', ran
dom_state=42)
    clf.fit(train_x_onehotCoding, train_y)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(train_x_onehotCoding, train_y)
    sig_clf_probs = sig_clf.predict(cv_x_onehotCoding)
    cv_f1_score_array.append(f1_score(cv_y, sig_clf_probs,average='macro'))
    # to avoid rounding error while multiplying probabilites we use log-probability est
imates
    print("f1_score :",f1_score(cv_y, sig_clf_probs,average='macro'))

fig, ax = plt.subplots()
ax.plot(alpha, cv_f1_score_array,c='g')
for i, txt in enumerate(np.round(cv_f1_score_array,3)):
    ax.annotate((alpha[i],str(txt)), (alpha[i],cv_f1_score_array[i]))
plt.grid()
plt.title("Cross Validation f1_score for each alpha")
plt.xlabel("Alpha i's")
plt.ylabel("f1_score")
plt.show()


best_alpha = np.argmin(cv_f1_score_array)
clf = SGDClassifier(class_weight='balanced', alpha=alpha[best_alpha], penalty='l2', los
s='log', random_state=42)
clf.fit(train_x_onehotCoding, train_y)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(train_x_onehotCoding, train_y)

predict_y = sig_clf.predict(train_x_onehotCoding)
print('For values of best alpha = ', alpha[best_alpha], "The train f1_score is:",f1_sco
re(y_train, predict_y,average='macro'))
predict_y = sig_clf.predict(cv_x_onehotCoding)
print('For values of best alpha = ', alpha[best_alpha], "The cross validation f1_score
 is:",f1_score(y_cv, predict_y,average='macro'))
predict_y = sig_clf.predict(test_x_onehotCoding)
print('For values of best alpha = ', alpha[best_alpha], "The test f1_score is:",f1_scor
e(y_test, predict_y,average='macro'))
```

```
for alpha = 1e-06
f1_score : 0.2800274536719286
for alpha = 1e-05
f1_score : 0.28455439646315056
for alpha = 0.0001
f1_score : 0.29745730240387935
for alpha = 0.001
f1_score : 0.30562511053812286
for alpha = 0.01
f1_score : 0.2800274536719286
for alpha = 0.1
f1_score : 0.2800274536719286
for alpha = 1
f1_score : 0.2800274536719286
for alpha = 10
f1_score : 0.2800274536719286
for alpha = 100
f1_score : 0.2800274536719286
```



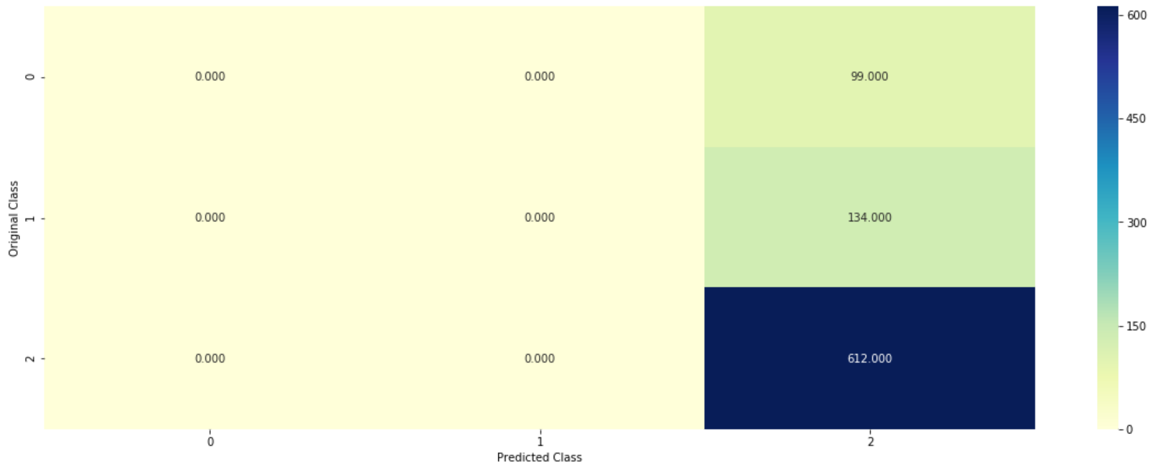

```
For values of best alpha =  1e-06 The train f1_score is: 0.346435389669630
4
For values of best alpha =  1e-06 The cross validation f1_score is: 0.2800
274536719286
For values of best alpha =  1e-06 The test f1_score is: 0.2855961243058017
```

Testing the model with best hyper paramters

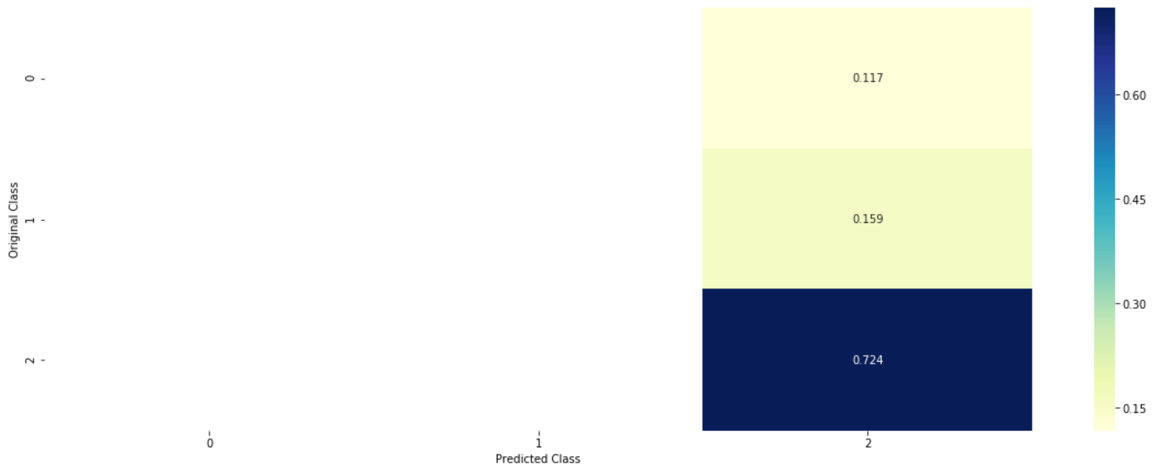
In [139]:

```
clf = SGDClassifier(class_weight='balanced', alpha=alpha[best_alpha], penalty='l2', los
s='log', random_state=42)
predict_and_plot_confusion_matrix(train_x_onehotCoding, train_y, cv_x_onehotCoding, cv_
y, clf)
```

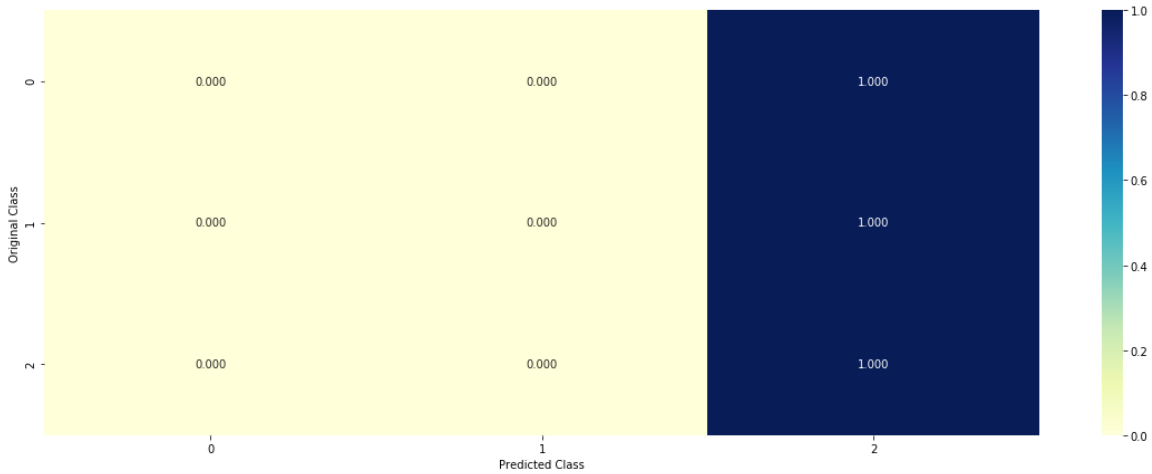
```
f1 score : 0.2800274536719286
Number of mis-classified points : 0.2757396449704142
-------------------- Confusion matrix --------------------
```




```
-------------------- Precision matrix (Columm Sum=1) --------------------
```




```
-------------------- Recall matrix (Row sum=1) --------------------
```

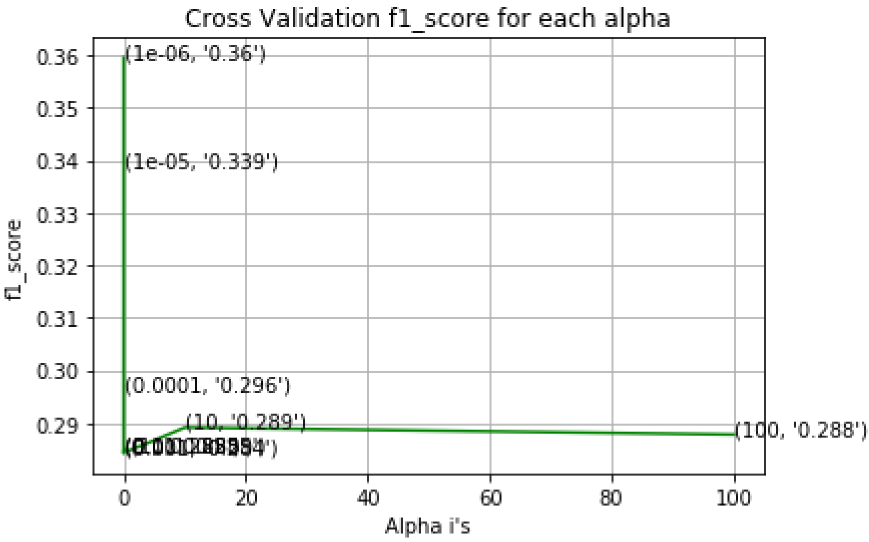


with response encoding

In [140]:

```
alpha = [10 ** x for x in range(-6, 3)]
cv_f1_score_array = []
for i in alpha:
    print("for alpha =", i)
    clf = SGDClassifier(class_weight='balanced', alpha=i, penalty='l2', loss='log', ran
dom_state=42)
    clf.fit(train_x_responseCoding, train_y)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(train_x_responseCoding, train_y)
    sig_clf_probs = sig_clf.predict(cv_x_responseCoding)
    cv_f1_score_array.append(f1_score(cv_y, sig_clf_probs,average='macro'))
    # to avoid rounding error while multiplying probabilites we use log-probability est
imates
    print("f1_score :",f1_score(cv_y, sig_clf_probs,average='macro'))

fig, ax = plt.subplots()
ax.plot(alpha, cv_f1_score_array,c='g')
for i, txt in enumerate(np.round(cv_f1_score_array,3)):
    ax.annotate((alpha[i],str(txt)), (alpha[i],cv_f1_score_array[i]))
plt.grid()
plt.title("Cross Validation f1_score for each alpha")
plt.xlabel("Alpha i's")
plt.ylabel("f1_score")
plt.show()


best_alpha = np.argmin(cv_f1_score_array)
clf = SGDClassifier(class_weight='balanced', alpha=alpha[best_alpha], penalty='l2', los
s='log', random_state=42)
clf.fit(train_x_responseCoding, train_y)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(train_x_responseCoding, train_y)

predict_y = sig_clf.predict(train_x_responseCoding)
print('For values of best alpha = ', alpha[best_alpha], "The train f1_score is:",f1_sco
re(y_train, predict_y,average='macro'))
predict_y = sig_clf.predict(cv_x_responseCoding)
print('For values of best alpha = ', alpha[best_alpha], "The cross validation f1_score
 is:",f1_score(y_cv, predict_y,average='macro'))
predict_y = sig_clf.predict(test_x_responseCoding)
print('For values of best alpha = ', alpha[best_alpha], "The test f1_score is:",f1_scor
e(y_test, predict_y,average='macro'))
```

```
for alpha = 1e-06
f1_score : 0.35953894554504595
for alpha = 1e-05
f1_score : 0.3389264681137473
for alpha = 0.0001
f1_score : 0.29621424382615497
for alpha = 0.001
f1_score : 0.28425280362800937
for alpha = 0.01
f1_score : 0.28485614176942253
for alpha = 0.1
f1_score : 0.28485614176942253
for alpha = 1
f1_score : 0.28485614176942253
for alpha = 10
f1_score : 0.28920665120795924
for alpha = 100
f1_score : 0.2878691290293501
```

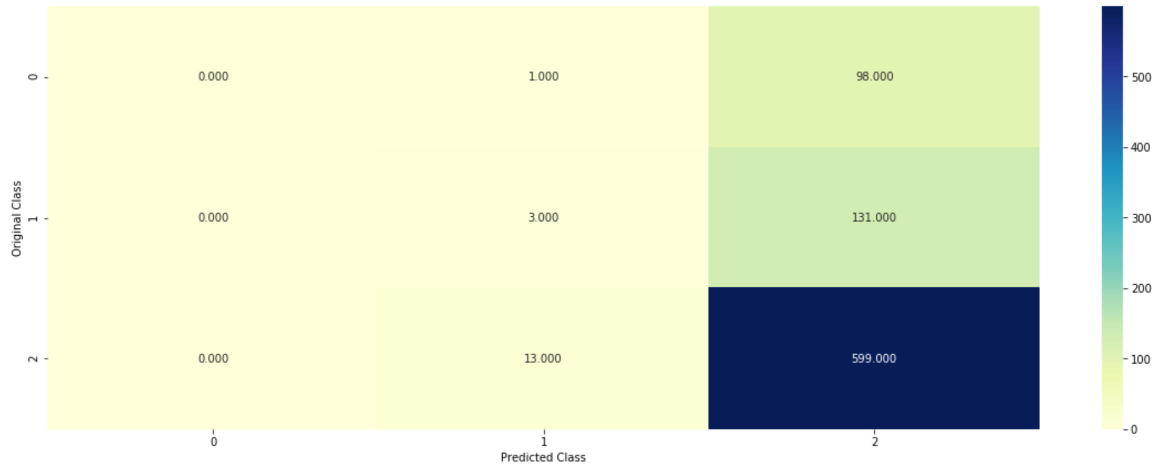



```
For values of best alpha =  0.001 The train f1_score is: 0.289603041760694
24
For values of best alpha =  0.001 The cross validation f1_score is: 0.2842
5280362800937
For values of best alpha =  0.001 The test f1_score is: 0.2785136129506990
4
```

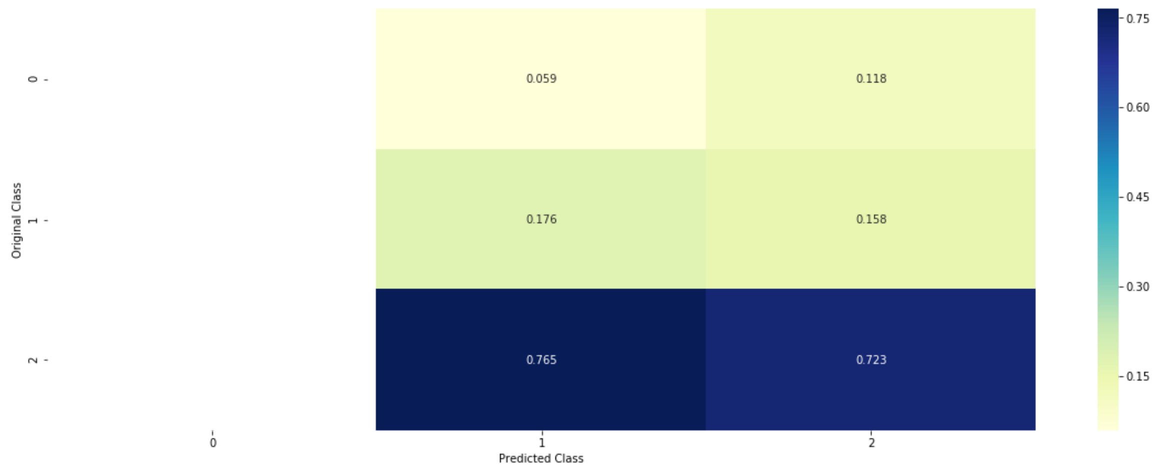
In [131]:

```
clf = SGDClassifier(class_weight='balanced', alpha=alpha[best_alpha], penalty='l2', los
s='log', random_state=42)
predict_and_plot_confusion_matrix(train_x_responseCoding, train_y, cv_x_responseCoding,
cv_y, clf)
```

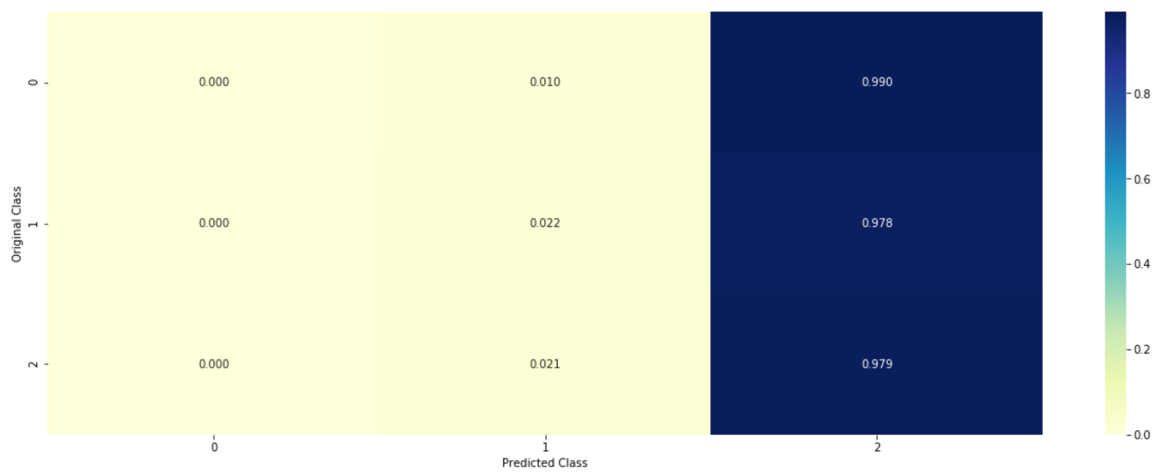
```
f1 score : 0.2905598479273976
Number of mis-classified points : 0.2875739644970414
-------------------- Confusion matrix --------------------
```




```
-------------------- Precision matrix (Columm Sum=1) --------------------
```




```
-------------------- Recall matrix (Row sum=1) --------------------
```



In [ ]:

```

```

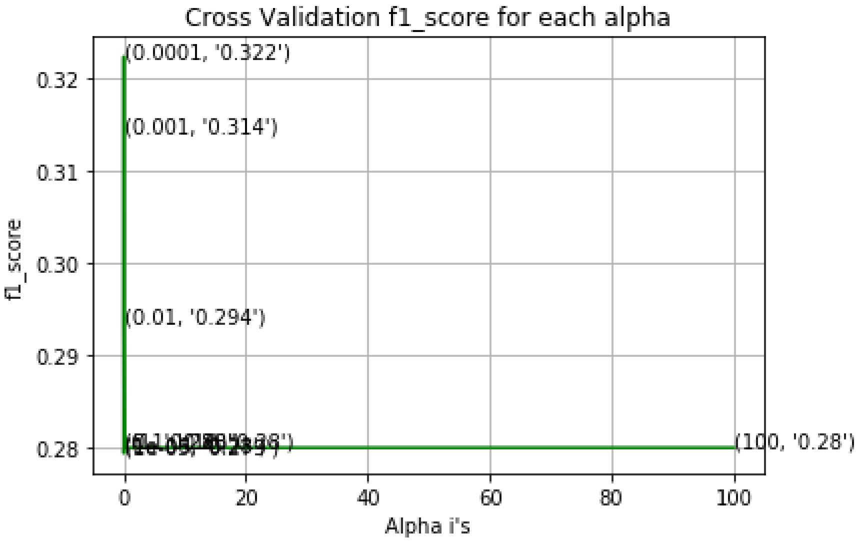
Logistic regression Without Class balancing

Hyperparameter tuningg

In [135]:

```
alpha = [10 ** x for x in range(-6, 3)]
cv_f1_score_array = []
for i in alpha:
    print("for alpha =", i)
    clf = SGDClassifier( alpha=i, penalty='l2', loss='log', random_state=42)
    clf.fit(train_x_onehotCoding, train_y)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(train_x_onehotCoding, train_y)
    sig_clf_probs = sig_clf.predict(cv_x_onehotCoding)
    cv_f1_score_array.append(f1_score(cv_y, sig_clf_probs,average='macro'))
    # to avoid rounding error while multiplying probabilites we use log-probability est
imates
    print("f1_score :",f1_score(cv_y, sig_clf_probs,average='macro'))

fig, ax = plt.subplots()
ax.plot(alpha, cv_f1_score_array,c='g')
for i, txt in enumerate(np.round(cv_f1_score_array,3)):
    ax.annotate((alpha[i],str(txt)), (alpha[i],cv_f1_score_array[i]))
plt.grid()
plt.title("Cross Validation f1_score for each alpha")
plt.xlabel("Alpha i's")
plt.ylabel("f1_score")
plt.show()


best_alpha = np.argmin(cv_f1_score_array)
clf = SGDClassifier( alpha=alpha[best_alpha], penalty='l2', loss='log', random_state=42
)
clf.fit(train_x_onehotCoding, train_y)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(train_x_onehotCoding, train_y)

predict_y = sig_clf.predict(train_x_onehotCoding)
print('For values of best alpha = ', alpha[best_alpha], "The train f1_score is:",f1_sco
re(y_train, predict_y,average='macro'))
predict_y = sig_clf.predict(cv_x_onehotCoding)
print('For values of best alpha = ', alpha[best_alpha], "The cross validation f1_score
 is:",f1_score(y_cv, predict_y,average='macro'))
predict_y = sig_clf.predict(test_x_onehotCoding)
print('For values of best alpha = ', alpha[best_alpha], "The test f1_score is:",f1_scor
e(y_test, predict_y,average='macro'))
```

```
for alpha = 1e-06
f1_score : 0.2797619047619047
for alpha = 1e-05
f1_score : 0.2794218857536132
for alpha = 0.0001
f1_score : 0.3222805788982259
for alpha = 0.001
f1_score : 0.3142583732057416
for alpha = 0.01
f1_score : 0.29364507871764267
for alpha = 0.1
f1_score : 0.2800274536719286
for alpha = 1
f1_score : 0.2800274536719286
for alpha = 10
f1_score : 0.2800274536719286
for alpha = 100
f1_score : 0.2800274536719286
```



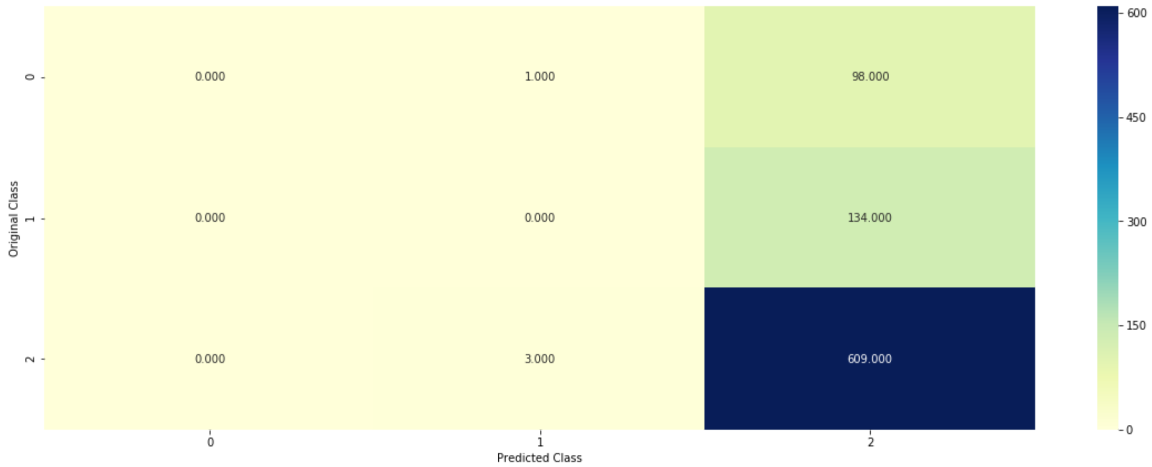

```
For values of best alpha =  1e-05 The train f1_score is: 0.307603680622971
05
For values of best alpha =  1e-05 The cross validation f1_score is: 0.2794
218857536132
For values of best alpha =  1e-05 The test f1_score is: 0.2839288986622686
```

Testing model with best hyper parameters

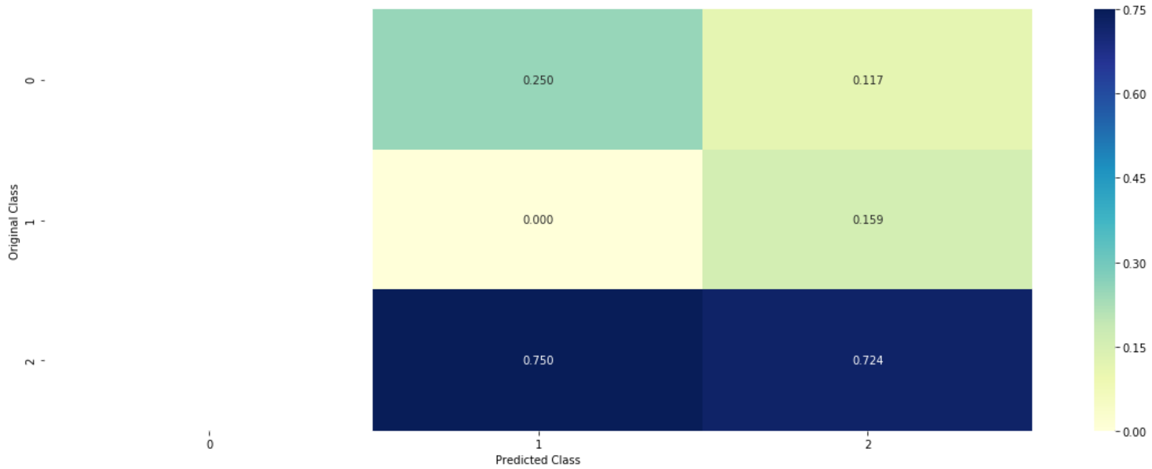
In [136]:

```
clf = SGDClassifier(alpha=alpha[best_alpha], penalty='l2', loss='log', random_state=42)
predict_and_plot_confusion_matrix(train_x_onehotCoding, train_y, cv_x_onehotCoding, cv_
y, clf)
```

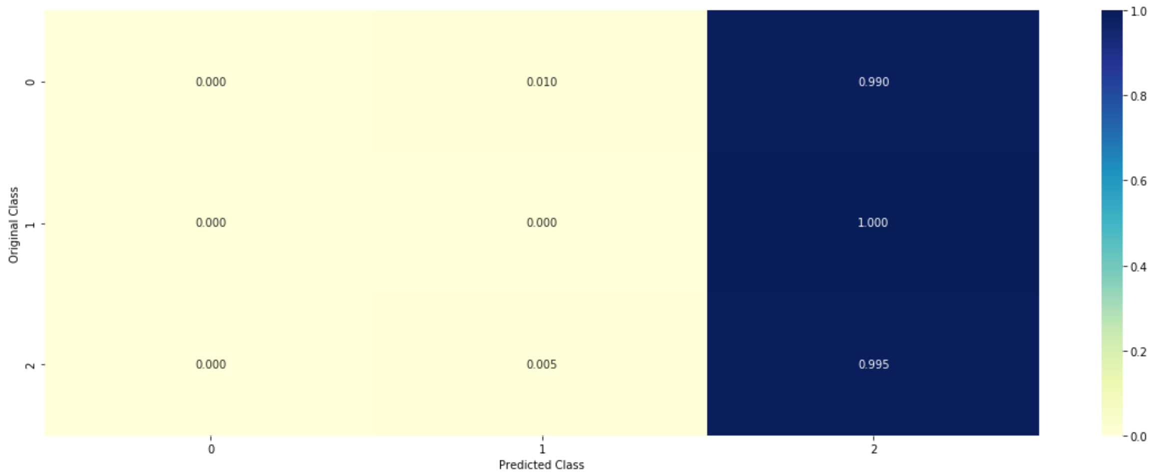
```
f1 score : 0.2794218857536132
Number of mis-classified points : 0.27928994082840236
-------------------- Confusion matrix --------------------
```




```
-------------------- Precision matrix (Columm Sum=1) --------------------
```




```
-------------------- Recall matrix (Row sum=1) --------------------
```



In [ ]:

```

```

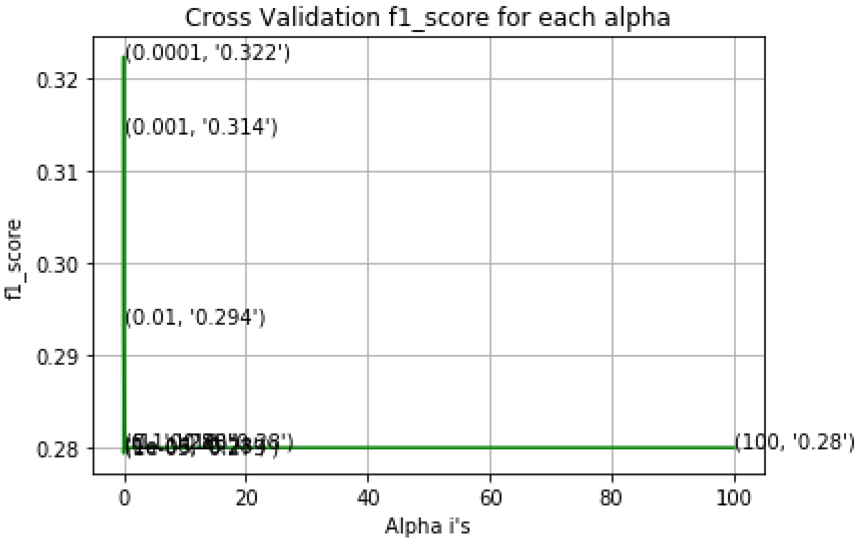
Linear Support Vector Machines

Hyper paramter tuning

In [137]:

```
alpha = [10 ** x for x in range(-6, 3)]
cv_f1_score_array = []
for i in alpha:
    print("for alpha =", i)
    clf = SGDClassifier( alpha=i, penalty='l2', loss='hinge', random_state=42)
    clf.fit(train_x_onehotCoding, train_y)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(train_x_onehotCoding, train_y)
    sig_clf_probs = sig_clf.predict(cv_x_onehotCoding)
    cv_f1_score_array.append(f1_score(cv_y, sig_clf_probs,average='macro'))
    # to avoid rounding error while multiplying probabilites we use log-probability est
imates
    print("f1_score :",f1_score(cv_y, sig_clf_probs,average='macro'))

fig, ax = plt.subplots()
ax.plot(alpha, cv_f1_score_array,c='g')
for i, txt in enumerate(np.round(cv_f1_score_array,3)):
    ax.annotate((alpha[i],str(txt)), (alpha[i],cv_f1_score_array[i]))
plt.grid()
plt.title("Cross Validation f1_score for each alpha")
plt.xlabel("Alpha i's")
plt.ylabel("f1_score")
plt.show()


best_alpha = np.argmin(cv_f1_score_array)
clf = SGDClassifier( alpha=alpha[best_alpha], penalty='l2', loss='hinge', random_state=
42)
clf.fit(train_x_onehotCoding, train_y)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(train_x_onehotCoding, train_y)

predict_y = sig_clf.predict(train_x_onehotCoding)
print('For values of best alpha = ', alpha[best_alpha], "The train f1_score is:",f1_sco
re(y_train, predict_y,average='macro'))
predict_y = sig_clf.predict(cv_x_onehotCoding)
print('For values of best alpha = ', alpha[best_alpha], "The cross validation f1_score
 is:",f1_score(y_cv, predict_y,average='macro'))
predict_y = sig_clf.predict(test_x_onehotCoding)
print('For values of best alpha = ', alpha[best_alpha], "The test f1_score is:",f1_scor
e(y_test, predict_y,average='macro'))
```

```
for alpha = 1e-06
f1_score : 0.2797619047619047
for alpha = 1e-05
f1_score : 0.2794218857536132
for alpha = 0.0001
f1_score : 0.3222805788982259
for alpha = 0.001
f1_score : 0.3142583732057416
for alpha = 0.01
f1_score : 0.29364507871764267
for alpha = 0.1
f1_score : 0.2800274536719286
for alpha = 1
f1_score : 0.2800274536719286
for alpha = 10
f1_score : 0.2800274536719286
for alpha = 100
f1_score : 0.2800274536719286
```



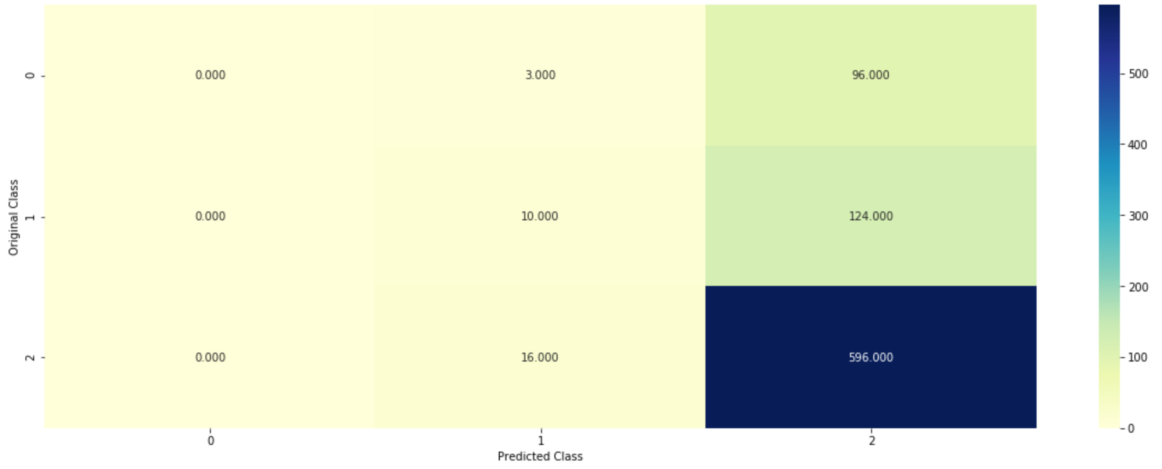

```
For values of best alpha =  1e-05 The train f1_score is: 0.307603680622971
05
For values of best alpha =  1e-05 The cross validation f1_score is: 0.2794
218857536132
For values of best alpha =  1e-05 The test f1_score is: 0.2839288986622686
```

Testing model with best hyper parameters

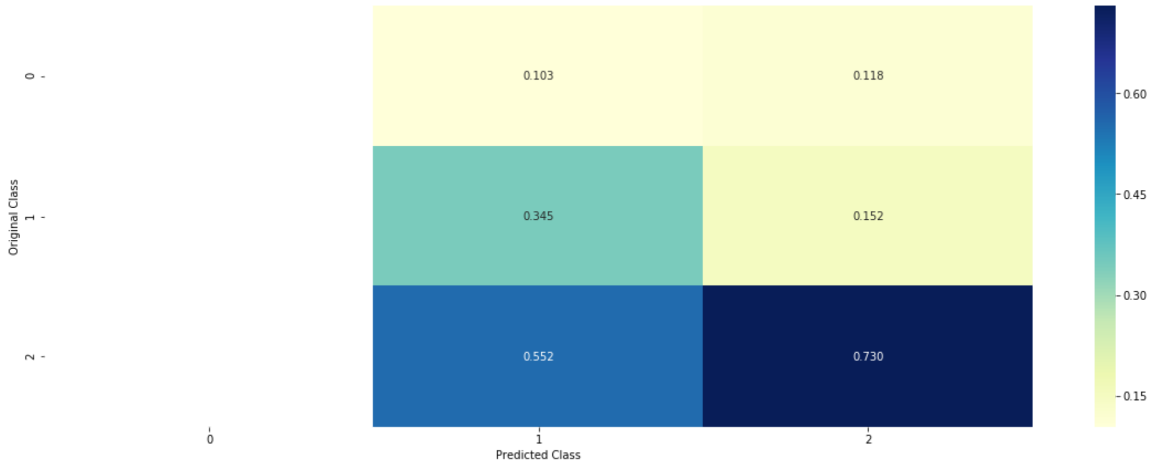
In [141]:

```
# clf = SVC(C=alpha[best_alpha],kernel='linear',probability=True, class_weight='balance
d')
clf = SGDClassifier(alpha=alpha[best_alpha], penalty='l2', loss='hinge', random_state=4
2,class_weight='balanced')
predict_and_plot_confusion_matrix(train_x_onehotCoding, train_y,cv_x_onehotCoding,cv_y,
clf)
```

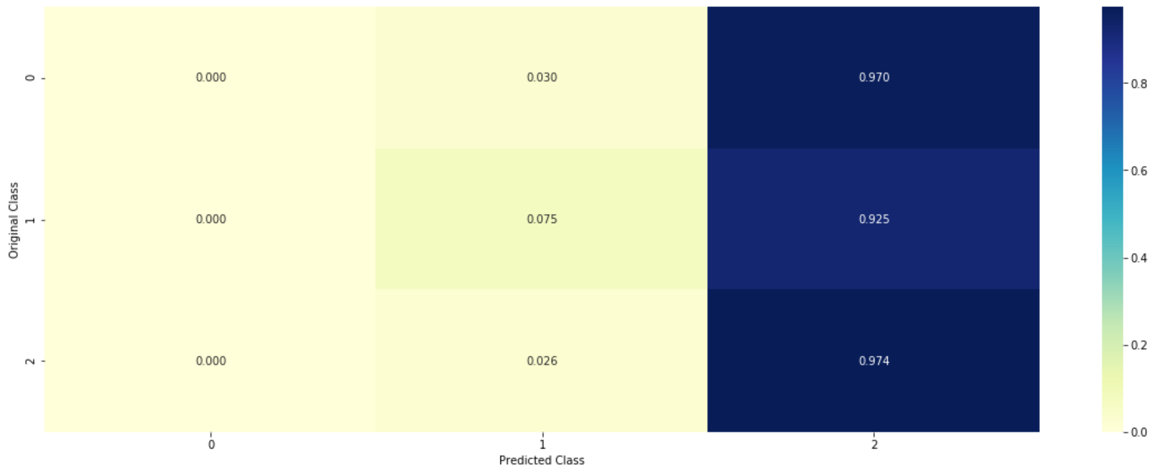
```
f1 score : 0.31914442668683013
Number of mis-classified points : 0.2828402366863905
-------------------- Confusion matrix --------------------
```




```
-------------------- Precision matrix (Columm Sum=1) --------------------
```




```
-------------------- Recall matrix (Row sum=1) --------------------
```



Random Forest Classifier with one hot encoding

In [142]:

```
alpha = [100,200,500,1000,2000]
max_depth = [5, 10]
cv_f1_score_array = []
for i in alpha:
    for j in max_depth:
        print("for n_estimators =", i,"and max depth = ", j)
        clf = RandomForestClassifier(n_estimators=i, criterion='gini', max_depth=j, ran
dom_state=42, n_jobs=-1)
        clf.fit(train_x_onehotCoding, train_y)
        sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
        sig_clf.fit(train_x_onehotCoding, train_y)
        sig_clf_probs = sig_clf.predict(cv_x_onehotCoding)
        cv_f1_score_array.append(f1_score(cv_y, sig_clf_probs,average='macro'))
        print("f1_score :",f1_score(cv_y, sig_clf_probs,average='macro'))

'''fig, ax = plt.subplots()
features = np.dot(np.array(alpha)[:,None],np.array(max_depth)[None]).ravel()
ax.plot(features, cv_log_error_array,c='g')
for i, txt in enumerate(np.round(cv_log_error_array,3)):
    ax.annotate((alpha[int(i/2)],max_depth[int(i%2)],str(txt)), (features[i],cv_log_err
or_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.argmax(cv_f1_score_array)
clf = RandomForestClassifier(n_estimators=alpha[int(best_alpha/2)], criterion='gini', m
ax_depth=max_depth[int(best_alpha%2)], random_state=42, n_jobs=-1)
clf.fit(train_x_onehotCoding, train_y)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(train_x_onehotCoding, train_y)

predict_y = sig_clf.predict(train_x_onehotCoding)
print('For values of best estimator = ', alpha[int(best_alpha/2)], "The train f1_score
 is:",f1_score(y_train, predict_y,average='macro'))
predict_y = sig_clf.predict(cv_x_onehotCoding)
print('For values of best estimator = ', alpha[int(best_alpha/2)], "The cross validatio
n f1_score is:",f1_score(y_cv, predict_y,average='macro'))
predict_y = sig_clf.predict(test_x_onehotCoding)
print('For values of best estimator = ', alpha[int(best_alpha/2)], "The test f1_score i
s:",f1_score(y_test, predict_y,average='macro'))
```

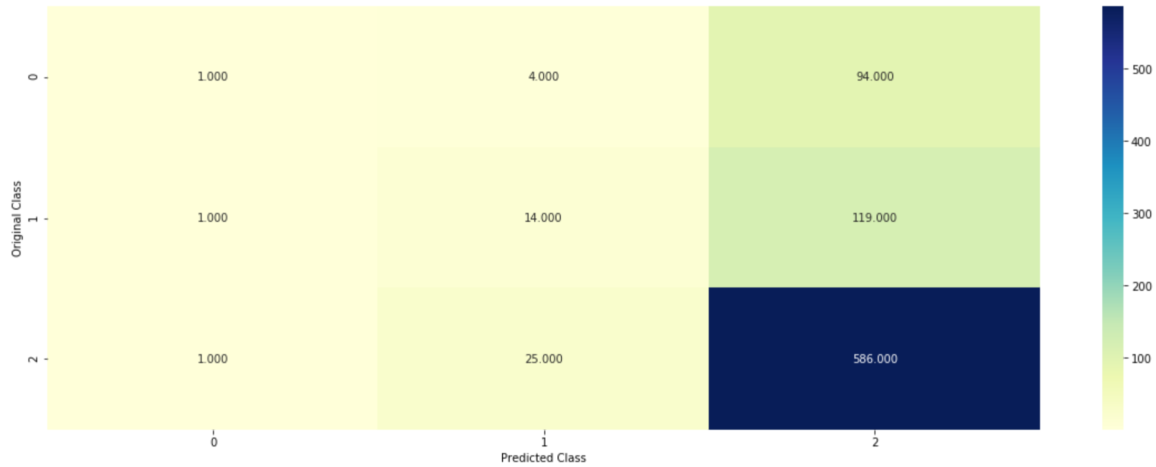
```
for n_estimators = 100 and max depth =  5
f1_score : 0.31703361669128727
for n_estimators = 100 and max depth =  10
f1_score : 0.328929125758424
for n_estimators = 200 and max depth =  5
f1_score : 0.3222612633715936
for n_estimators = 200 and max depth =  10
f1_score : 0.3322216781236876
for n_estimators = 500 and max depth =  5
f1_score : 0.32796934237087855
for n_estimators = 500 and max depth =  10
f1_score : 0.3332330323751749
for n_estimators = 1000 and max depth =  5
f1_score : 0.32527155040697836
for n_estimators = 1000 and max depth =  10
f1_score : 0.3337965537953425
for n_estimators = 2000 and max depth =  5
f1_score : 0.3361388391719087
for n_estimators = 2000 and max depth =  10
f1_score : 0.3317756120947611
For values of best estimator =  2000 The train f1_score is: 0.425765130525
62664
For values of best estimator =  2000 The cross validation f1_score is: 0.3
361388391719087
For values of best estimator =  2000 The test f1_score is: 0.3401934317941
0483
```

Testing model with best hyper parameters (One Hot Encoding)

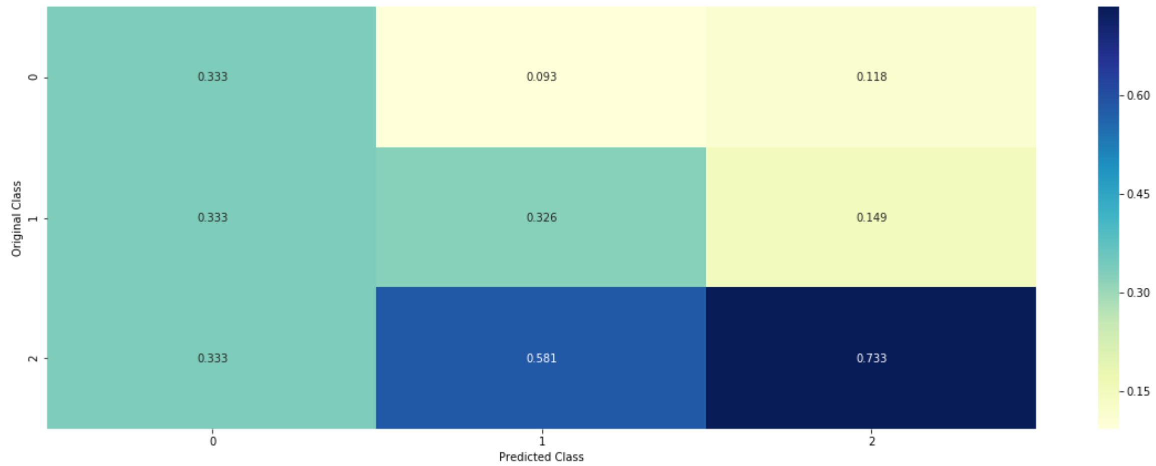
In [143]:

```
clf = RandomForestClassifier(n_estimators=2000, criterion='gini', max_depth=5, random_s
tate=42, n_jobs=-1)
predict_and_plot_confusion_matrix(train_x_onehotCoding, train_y,cv_x_onehotCoding,cv_y,
clf)
```

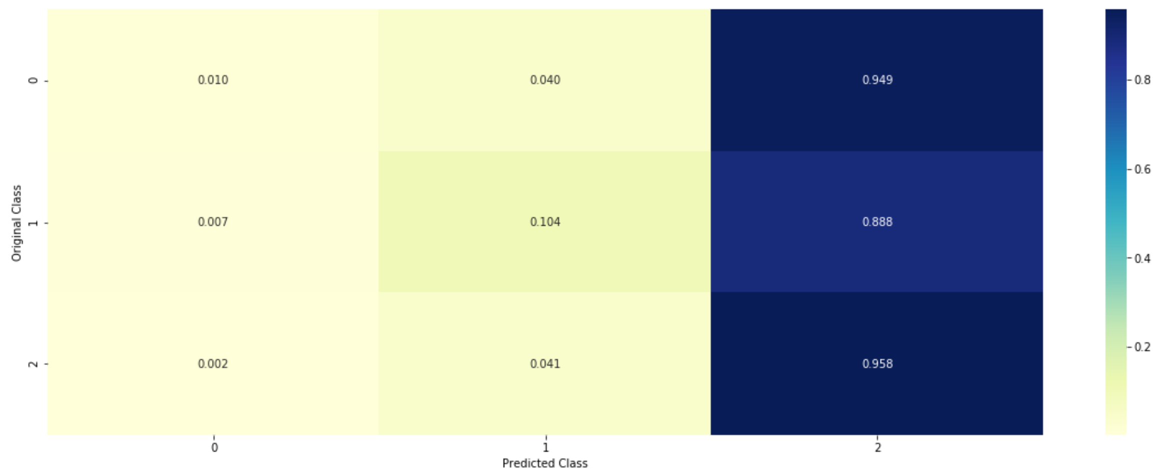
```
f1 score : 0.3361388391719087
Number of mis-classified points : 0.28875739644970416
-------------------- Confusion matrix --------------------
```




```
-------------------- Precision matrix (Columm Sum=1) --------------------
```




```
-------------------- Recall matrix (Row sum=1) --------------------
```



Hyper paramter tuning (With Response Coding)

In [165]:

```
alpha = [100,200,500,1000,2000]
max_depth = [5, 10]
cv_f1_score_array = []
for i in alpha:
    for j in max_depth:
        print("for n_estimators =", i,"and max depth = ", j)
        clf = RandomForestClassifier(n_estimators=i, criterion='gini', max_depth=j, ran
dom_state=42, n_jobs=-1)
        clf.fit(train_x_responseCoding, train_y)
        sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
        sig_clf.fit(train_x_responseCoding, train_y)
        sig_clf_probs = sig_clf.predict(cv_x_responseCoding)
        cv_f1_score_array.append(f1_score(cv_y, sig_clf_probs,average='macro'))
        print("f1_score :",f1_score(cv_y, sig_clf_probs,average='macro'))

'''fig, ax = plt.subplots()
features = np.dot(np.array(alpha)[:,None],np.array(max_depth)[None]).ravel()
ax.plot(features, cv_log_error_array,c='g')
for i, txt in enumerate(np.round(cv_log_error_array,3)):
    ax.annotate((alpha[int(i/2)],max_depth[int(i%2)],str(txt)), (features[i],cv_log_err
or_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.argmax(cv_f1_score_array)
clf = RandomForestClassifier(n_estimators=alpha[int(best_alpha/2)], criterion='gini', m
ax_depth=max_depth[int(best_alpha%2)], random_state=42, n_jobs=-1)
clf.fit(train_x_responseCoding, train_y)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(train_x_responseCoding, train_y)

predict_y = sig_clf.predict(train_x_responseCoding)
print('For values of best estimator = ', alpha[int(best_alpha/2)], "The train f1_score
 is:",f1_score(y_train, predict_y,average='macro'))
predict_y = sig_clf.predict(cv_x_responseCoding)
print('For values of best estimator = ', alpha[int(best_alpha/2)], "The cross validatio
n f1_score is:",f1_score(y_cv, predict_y,average='macro'))
predict_y1 = sig_clf.predict(test_x_responseCoding)
print('For values of best estimator = ', alpha[int(best_alpha/2)], "The test f1_score i
s:",f1_score(y_test, predict_y1,average='macro'))
```

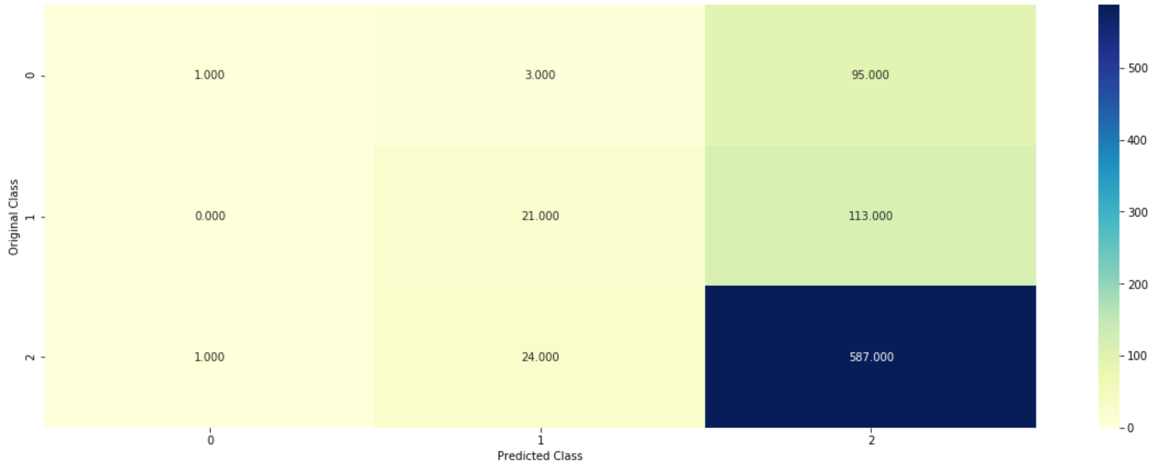
```
for n_estimators = 100 and max depth =  5
f1_score : 0.34578326985111496
for n_estimators = 100 and max depth =  10
f1_score : 0.3582010911726532
for n_estimators = 200 and max depth =  5
f1_score : 0.3470981903844095
for n_estimators = 200 and max depth =  10
f1_score : 0.36061875112723274
for n_estimators = 500 and max depth =  5
f1_score : 0.34729082593489374
for n_estimators = 500 and max depth =  10
f1_score : 0.36131582880808893
for n_estimators = 1000 and max depth =  5
f1_score : 0.3512973245835436
for n_estimators = 1000 and max depth =  10
f1_score : 0.3616568807938691
for n_estimators = 2000 and max depth =  5
f1_score : 0.3512973245835436
for n_estimators = 2000 and max depth =  10
f1_score : 0.36096019647903743
For values of best estimator =  1000 The train f1_score is: 0.526294545212
8246
For values of best estimator =  1000 The cross validation f1_score is: 0.3
616568807938691
For values of best estimator =  1000 The test f1_score is: 0.3582415252291
759
```

Testing model with best hyper parameters (Response Coding)

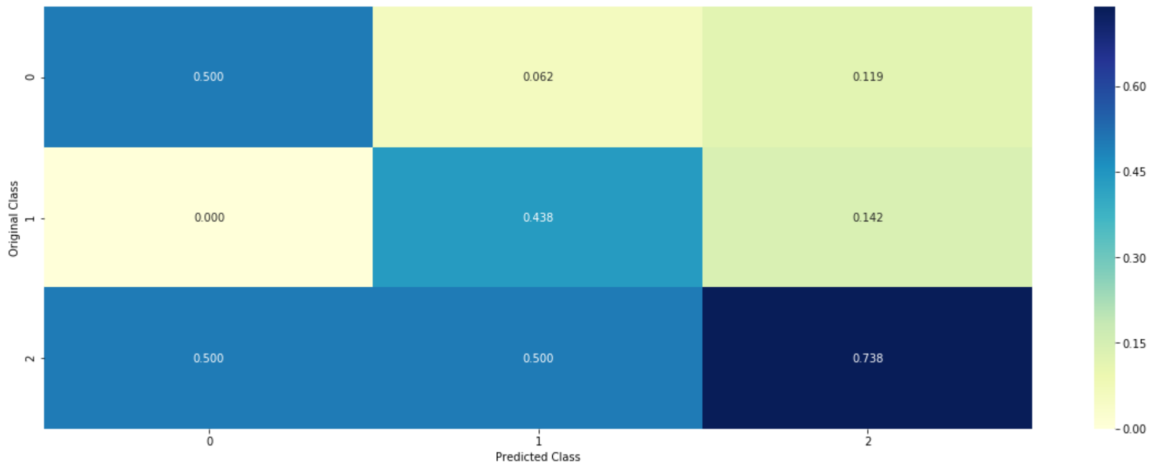
In [171]:

```
sig_clf = RandomForestClassifier(max_depth=10, n_estimators=1000, criterion='gini', max
_features='auto',random_state=42)
predict_and_plot_confusion_matrix(train_x_responseCoding, train_y,cv_x_responseCoding,c
v_y, clf)
```

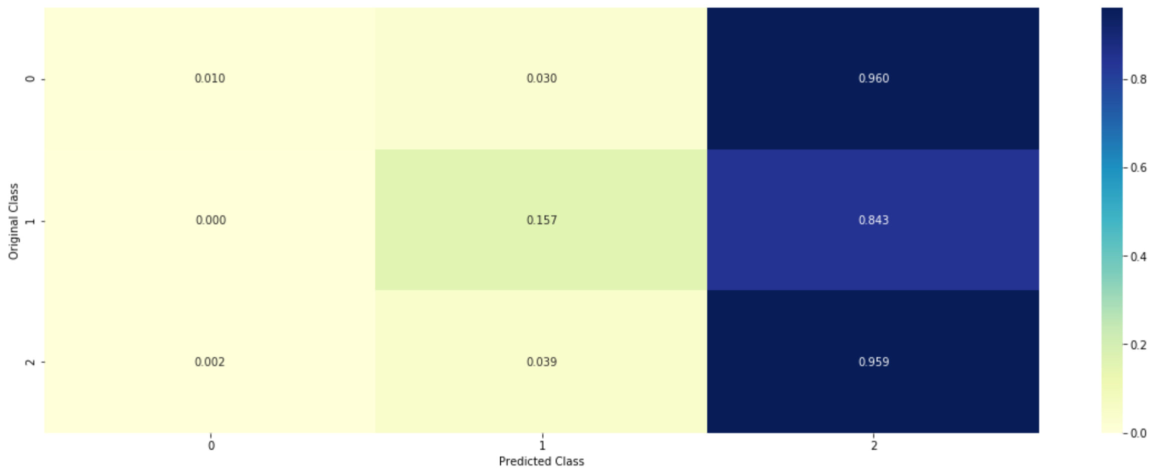
```
f1 score : 0.3616568807938691
Number of mis-classified points : 0.27928994082840236
-------------------- Confusion matrix --------------------
```




```
-------------------- Precision matrix (Columm Sum=1) --------------------
```




```
-------------------- Recall matrix (Row sum=1) --------------------
```



In [178]:

```
clf = RandomForestClassifier(n_estimators=1000, criterion='gini', max_depth=10, random_
state=42, n_jobs=-1)
clf.fit(train_x_responseCoding, train_y)
```

Out[178]:

```
RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gin
i',
                       max_depth=10, max_features='auto', max_leaf_nodes=N
one,
                       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=1000,
                       n_jobs=-1, oob_score=False, random_state=42, verbos
e=0,
                       warm_start=False)
```

In [182]:

```
predict_y1 = clf.predict(data_test_x_responseCoding)
```

In [183]:

```
type(predict_y1)
```

Out[183]:

```
numpy.ndarray
```

In [184]:

```
print(predict_y1)
new_series = pd.Series(predict_y1)
new_series.value_counts()
```

```
[2 2 2 ... 2 2 2]
```

Out[184]:

```
2    2923
1       1
dtype: int64
```

In [185]:

```
predictions = pd.DataFrame(new_series, columns=['sentiment'])
predictions.to_csv("sentiment_analysis_response.csv", index=False)
```

Stack the models

In [188]:

```
clf1 = SGDClassifier(alpha=1e-06, penalty='l2', loss='log', class_weight='balanced', ra
ndom_state=0)
clf1.fit(train_x_onehotCoding, train_y)
sig_clf1 = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf1.fit(train_x_onehotCoding, train_y)

clf2 = SGDClassifier(alpha=1e-05, penalty='l2', loss='hinge', class_weight='balanced',
random_state=0)
clf2.fit(train_x_onehotCoding, train_y)
sig_clf2 = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf2.fit(train_x_onehotCoding, train_y)


clf3 = MultinomialNB(alpha=1e-05)
clf3.fit(train_x_onehotCoding, train_y)
sig_clf3 = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf3.fit(train_x_onehotCoding, train_y)

clf4 = RandomForestClassifier(max_depth=10, n_estimators=1000, criterion='gini', max_fe
atures='auto',random_state=42)
clf4.fit(train_x_onehotCoding, train_y)
sig_clf4 = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf4.fit(train_x_onehotCoding, train_y)

clf5 = KNeighborsClassifier(n_neighbors=15)
clf5.fit(train_x_responseCoding, train_y)
sig_clf5 = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf5.fit(train_x_responseCoding, train_y)

print("f1_score :",f1_score(cv_y, sig_clf_probs,average='macro'))


print("Logistic Regression :  f1_score: %0.2f" % (f1_score(cv_y, sig_clf1.predict(cv_x_
onehotCoding),average='macro')))

print("Support vector machines :f1_score: %0.2f" % (f1_score(cv_y, sig_clf2.predict(cv_
x_onehotCoding),average='macro')))

print("Naive Bayes : f1_score: %0.2f" % (f1_score(cv_y, sig_clf3.predict(cv_x_onehotCod
ing),average='macro')))

print("Random forest : f1_score: %0.2f" % (f1_score(cv_y, sig_clf3.predict(cv_x_onehotC
oding),average='macro')))

print("KNN : f1_score: %0.2f" % (f1_score(cv_y, sig_clf3.predict(cv_x_onehotCoding),ave
rage='macro')))

print("-"*50)
alpha = [0.0001,0.001,0.01,0.1,1,10]
best_alpha = 999
for i in alpha:
    lr = LogisticRegression(C=i)
    sclf = StackingClassifier(classifiers=[sig_clf1, sig_clf2, sig_clf3,sig_clf4,sig_cl
f5], meta_classifier=lr, use_probas=True)
    sclf.fit(train_x_onehotCoding, train_y)
    print("Stacking Classifer : for the value of alpha: %f Log Loss: %0.3f" % (i, f1_sc
ore(cv_y, sclf.predict(cv_x_onehotCoding),average='macro')))
    log_error =f1_score(cv_y, sclf.predict(cv_x_onehotCoding),average='macro')
```

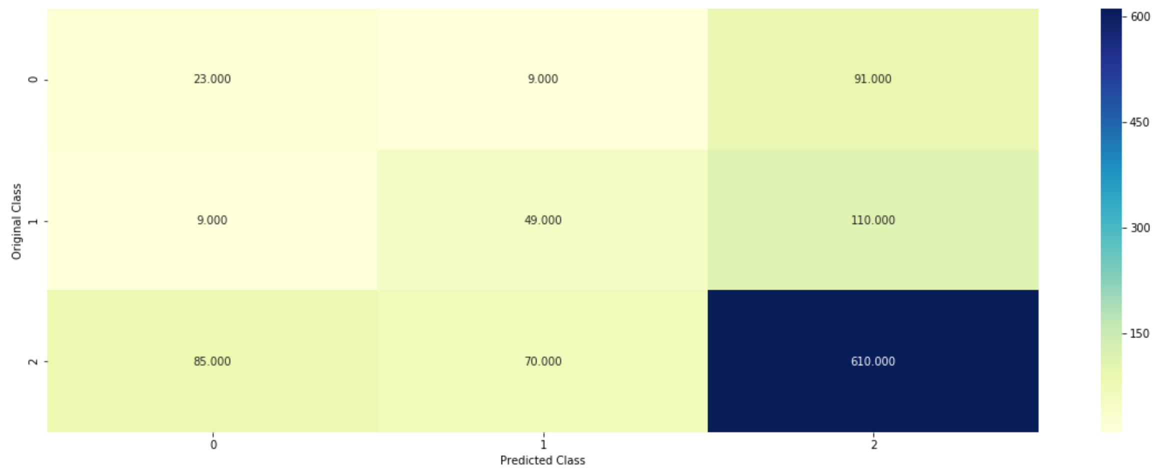
```
    if best_alpha > log_error:
        best_alpha = log_error
```

```
f1_score : 0.36096019647903743
Logistic Regression :  f1_score: 0.33
Support vector machines :f1_score: 0.33
Naive Bayes : f1_score: 0.33
Random forest : f1_score: 0.33
KNN : f1_score: 0.33
--------------------------------------------------
Stacking Classifer : for the value of alpha: 0.000100 Log Loss: 0.280
Stacking Classifer : for the value of alpha: 0.001000 Log Loss: 0.280
Stacking Classifer : for the value of alpha: 0.010000 Log Loss: 0.320
Stacking Classifer : for the value of alpha: 0.100000 Log Loss: 0.374
Stacking Classifer : for the value of alpha: 1.000000 Log Loss: 0.424
Stacking Classifer : for the value of alpha: 10.000000 Log Loss: 0.438
```

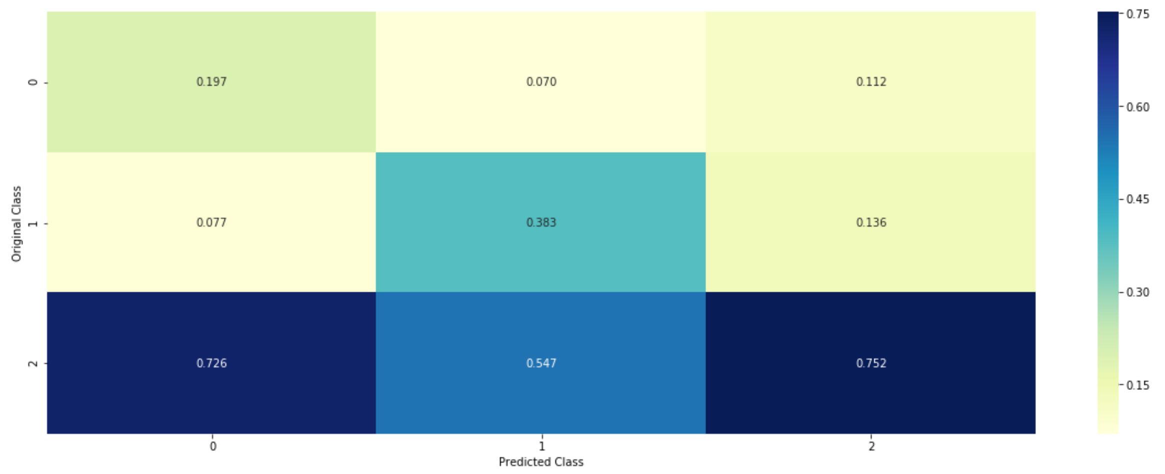
In [189]:

```
lr = LogisticRegression(C=19)
sclf = StackingClassifier(classifiers=[sig_clf1, sig_clf2, sig_clf3,sig_clf4,sig_clf5],
meta_classifier=lr, use_probas=True)
sclf.fit(train_x_onehotCoding, train_y)

log_error = f1_score(cv_y, sclf.predict(cv_x_onehotCoding),average='macro')
print("Log loss (train) on the stacking classifier :",log_error)

log_error = f1_score(cv_y, sclf.predict(cv_x_onehotCoding),average='macro')
print("Log loss (CV) on the stacking classifier :",log_error)

log_error = f1_score(cv_y, sclf.predict(cv_x_onehotCoding),average='macro')
print("Log loss (test) on the stacking classifier :",log_error)

print("Number of missclassified point :", np.count_nonzero((sclf.predict(test_x_onehotC
oding)- test_y))/test_y.shape[0])
plot_confusion_matrix(test_y=test_y, predict_y=sclf.predict(test_x_onehotCoding))
```

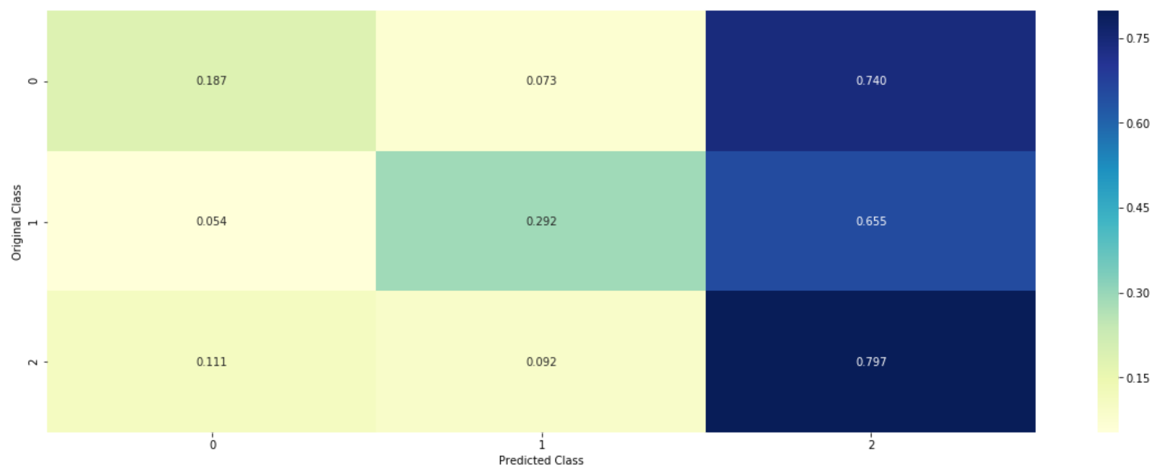
```
Log loss (train) on the stacking classifier : 0.4292674642596297
Log loss (CV) on the stacking classifier : 0.4292674642596297
Log loss (test) on the stacking classifier : 0.4292674642596297
Number of missclassified point : 0.3541666666666667
-------------------- Confusion matrix --------------------
```




```
-------------------- Precision matrix (Columm Sum=1) --------------------
```




```
-------------------- Recall matrix (Row sum=1) --------------------
```



In [194]:

```
predict_y1 = sclf.predict(data_test_x_onehotCoding)
print(predict_y1)
new_series = pd.Series(predict_y1)
new_series.value_counts()
```

```
[2 2 2 ... 2 2 2]
```

Out[194]:

```
2    2517
1     281
0     126
dtype: int64
```

In [198]:

```
predictions = pd.DataFrame(new_series, columns=['sentiment'])
predictions.to_csv("sentiment_analysis_submission.csv", index=False)
```

In [ ]:

```
```