In [205]:

```
import sqlite3
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn import datasets
from sklearn.naive_bayes import MultinomialNB
from matplotlib.colors import ListedColormap
from sklearn import cross_validation
from sklearn.metrics import accuracy_score
from sklearn.cross_validation import cross_val_score
from sklearn.metrics import confusion_matrix
from sklearn.metrics import f1_score
import scikitplot as skplt
```

Load data

In [206]:

```
#Data here used is preprocessed(deduplication,removal of html tags,punctuation,stop words,stemming)
con =sqlite3.connect(r'C:\Users\Friend\AI\AI_datasets\Amazon\cleaned_database.sqlite')
filtered_data  = pd.read_sql_query('SELECT * FROM Reviews WHERE Score != 3',con)
filtered_data = filtered_data.drop('index',axis = 1)

filtered_data = filtered_data.sort_values('Time')
```

Sampling data

In [207]:

```
data = filtered_data.head(300000)
data.columns
```

Out[207]:

```
Index(['Id', 'ProductId', 'UserId', 'ProfileName', 'HelpfulnessNumerator',
       'HelpfulnessDenominator', 'Score', 'Time', 'Summary', 'Text',
       'CleanedText'],
      dtype='object')
```

In [208]:

```
X_1, X_test, y_1, y_test = cross_validation.train_test_split(data['CleanedText'], data['Score'], test_s
ize=0.3, random_state=0)
X_train, X_cv, y_train, y_cv = cross_validation.train_test_split(X_1, y_1, test_size=0.3, random_state=
0)
print(X_cv.shape,y_cv.shape,X_train.shape,y_train.shape,X_test.shape,y_test.shape)
```

```
(63000,) (63000,) (147000,) (147000,) (90000,) (90000,)
```

BOW

In [209]:

```
# Performing BOW on review
from sklearn.feature_extraction.text import CountVectorizer
count_vect = CountVectorizer()
vocabulary = count_vect.fit(X_train)
```

In [210]:

```
bag_of_words_train = count_vect.transform(X_train)
print(bag_of_words_train.shape)
```

```
(147000, 45505)
```

In [211]:

```
bag_of_words_cv = count_vect.transform(X_cv)
print(bag_of_words_train.shape)
```

```
(147000, 45505)
```

Performance Metrics,cross validation

- Accuracy

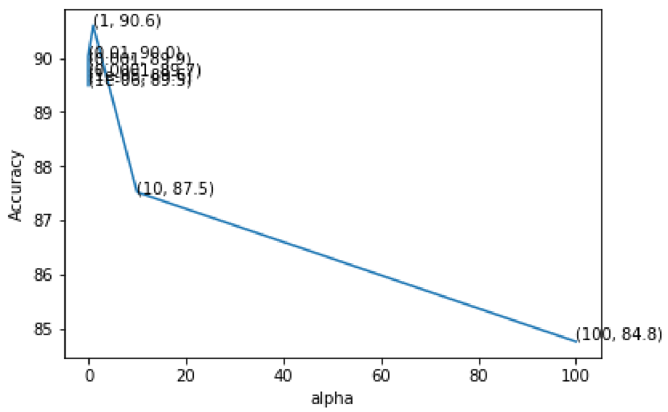
In [212]:

```
#cross validation for different alpha values using accuracy as performance metric.
alphas = [0.000001,0.00001, 0.0001, 0.001, 0.01, 1, 10, 100]
accuracy_bow = []
for alpha in alphas:
    nb = MultinomialNB(alpha=alpha)
    nb.fit(bag_of_words_train, y_train)
    pred = nb.predict(bag_of_words_cv)
    acc = accuracy_score(y_cv,pred, normalize=True) * float(100)
    accuracy_bow.append(acc)
```

In [213]:

```
alpha = alphas[accuracy_bow.index(max(accuracy_bow))]
print('At Alpha = ',alpha,'accuracy is ',max(accuracy_bow))
plt.plot(alphas,accuracy_bow)
for xy in zip(alphas, np.round(accuracy_bow,1)):
    plt.annotate('(%s, %s)' % xy, xy=xy, textcoords='data')
plt.xlabel('alpha')
plt.ylabel('Accuracy')
plt.show()
```

```
At Alpha =  1 accuracy is  90.6015873015873
```

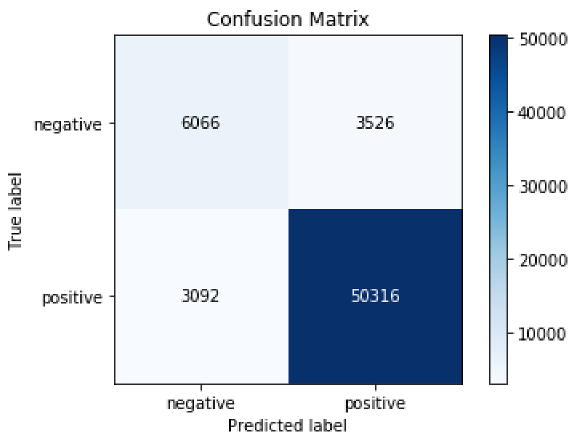


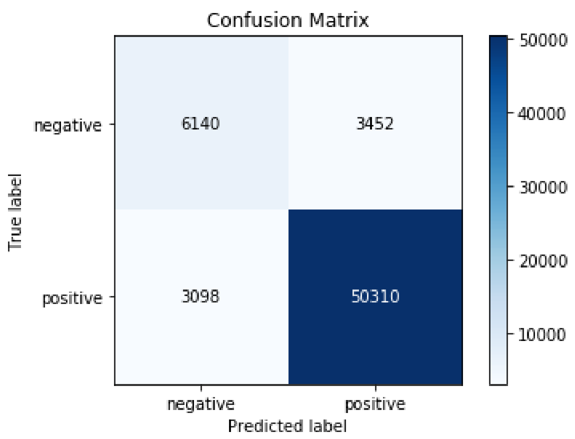
- confusion matrix

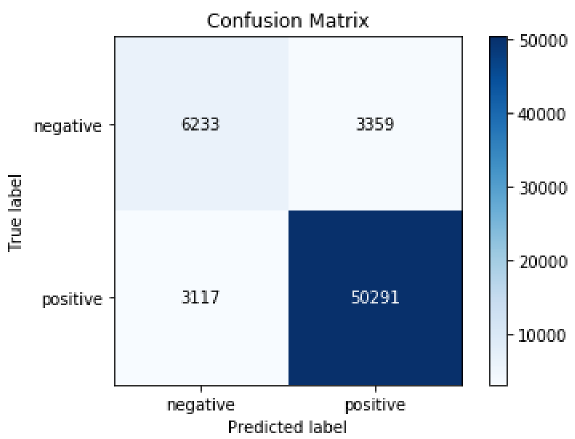
In [214]:

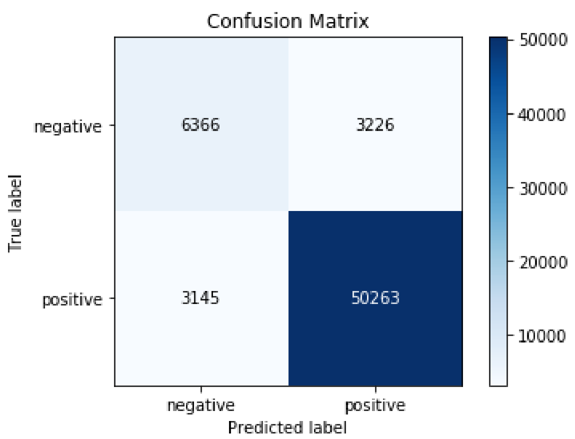
```
#cross validation for different alpha values using confusion matrix as performance metric.
alphas = [0.000001,0.00001, 0.0001, 0.001, 0.01, 1, 10, 100]
for alpha in alphas:
    nb = MultinomialNB(alpha=alpha)
```

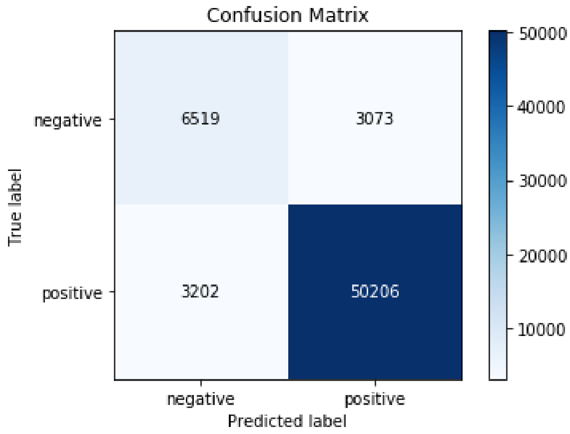
```
nb.fit(bag_of_words_train, y_train)
pred = nb.predict(bag_of_words_cv)
skplt.metrics.plot_confusion_matrix(y_cv, pred, normalize=False)
```

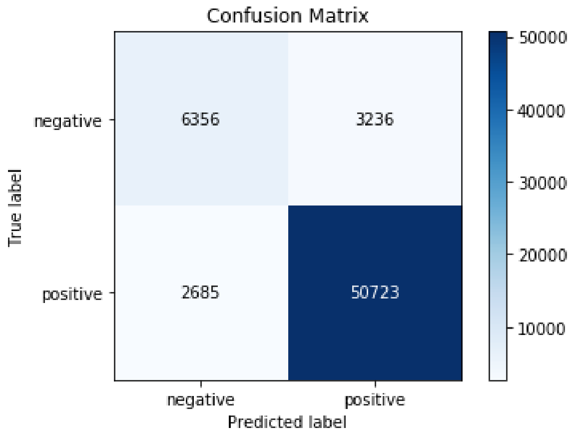


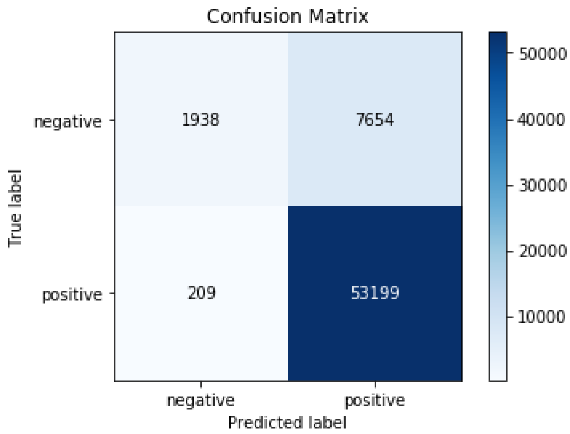


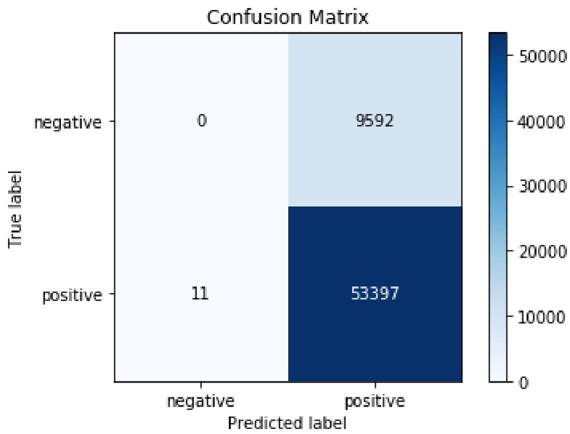












- F1 Score

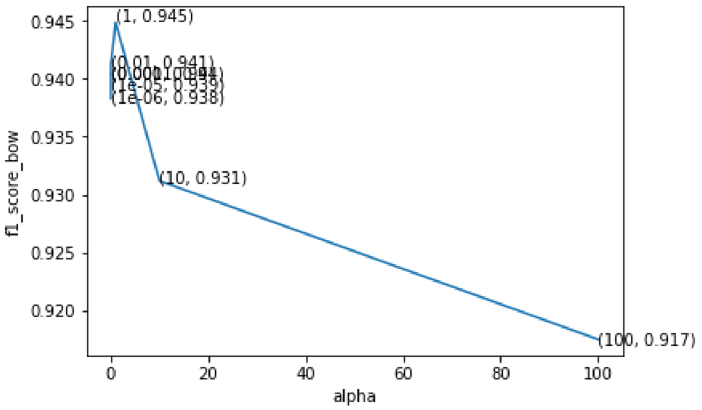
In [215]:

```
alphas = [0.000001,0.00001, 0.0001, 0.001, 0.01, 1, 10, 100]
f1_score_bow = []
for alpha in alphas:
    nb = MultinomialNB(alpha=alpha)
    nb.fit(bag_of_words_train, y_train)
    pred = nb.predict(bag_of_words_cv)
    tn, fp, fn, tp = confusion_matrix(y_cv, pred).ravel()
    pr,re = (tp)/(tp+fp),(tp)/(tp+fn)
    score=(2*pr*re)/(pr+re)
    f1_score_bow.append(score)
```

In [216]:

```
alpha_bow = alphas[f1_score_bow.index(max(f1_score_bow))]
print('At Alpha = ',alpha_bow,'f1_score is ',max(f1_score_bow))

plt.plot(alphas,f1_score_bow)
for xy in zip(alphas, np.round(f1_score_bow,3)):
    plt.annotate('(%s, %s)' % xy, xy=xy, textcoords='data')
plt.xlabel('alpha')
plt.ylabel('f1_score_bow')
plt.show()
```

```
At Alpha =  1 f1_score is  0.9448527014818333
```



In [241]:

```
f1_score_bow_train = max(f1_score_bow)
```

In [217]:

```
bag_of_words_test = count_vect.transform(X_test)
print(bag_of_words_test.shape)
```

```
(90000, 45505)
```

- Performing Naive Bayes for best alpha value.

In [220]:

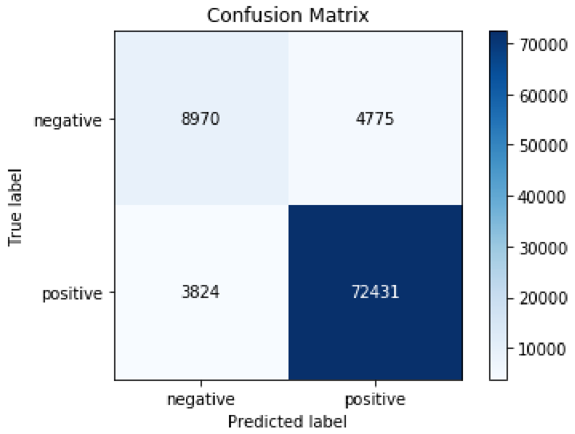
```
#Performing K-NN for optimal k-value using test data
nb = MultinomialNB(alpha=1)
nb.fit(bag_of_words_train, y_train)

#predicting using test data
pred = nb.predict(bag_of_words_test)

#Accuracy
acc = accuracy_score(y_test,pred, normalize=True) * float(100)
print('accuracy for alpha = 1 is',(acc))

#f1-score
tn, fp, fn, tp = confusion_matrix(y_test, pred).ravel()
pr,re = (tp)/(tp+fp),(tp)/(tp+fn)
```

```
f1_score_bow_test=(2*pr*re)/(pr+re)
print('f1 score for alpha = 1 is',(f1_score_bow_test))

#confusion matrix
skplt.metrics.plot_confusion_matrix(y_test, pred, normalize=False)
```

```
accuracy for alpha = 1 is 90.44555555555556
f1 score for alpha = 1 is 0.9439662194303438
```

Out[220]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x202989cfe48>
```



tfidf

In [222]:

```
# Performing BOW on review
from sklearn.feature_extraction.text import TfidfVectorizer

tf_idf_vect = TfidfVectorizer(ngram_range=(1,2))
vocabulary = tf_idf_vect.fit(X_train)
```

In [223]:

```
tf_idf_train = tf_idf_vect.transform(X_train)
print(tf_idf_train.shape)
```

```
(147000, 1631076)
```

In [224]:

```
tf_idf_cv = tf_idf_vect.transform(X_cv)
print(tf_idf_cv.shape)
```

```
(63000, 1631076)
```

Performance Metrics,cross validation

- Accuracy

In [225]:

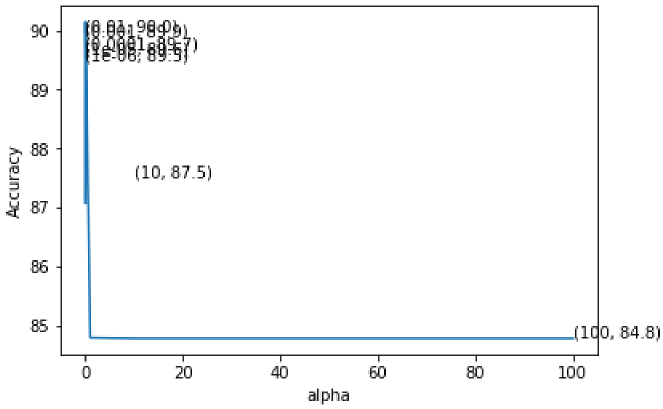
```
#cross validation for different alpha values using accuracy as performance metric.
alphas = [0.000001,0.00001, 0.0001, 0.001, 0.01, 1, 10, 100]
accuracy_tfidf = []
for alpha in alphas:
    nb = MultinomialNB(alpha=alpha)
```

```
    nb.fit(tf_idf_train, y_train)
    pred = nb.predict(tf_idf_cv)
    acc = accuracy_score(y_cv,pred, normalize=True) * float(100)
    accuracy_tfidf.append(acc)
```

In [227]:

```
alpha = alphas[accuracy_tfidf.index(max(accuracy_tfidf))]
print('At Alpha = ',alpha,'accuracy is ',max(accuracy_tfidf))
plt.plot(alphas,accuracy_tfidf)
for xy in zip(alphas, np.round(accuracy_bow,1)):
    plt.annotate('(%s, %s)' % xy, xy=xy, textcoords='data')
plt.xlabel('alpha')
plt.ylabel('Accuracy')
plt.show()
```

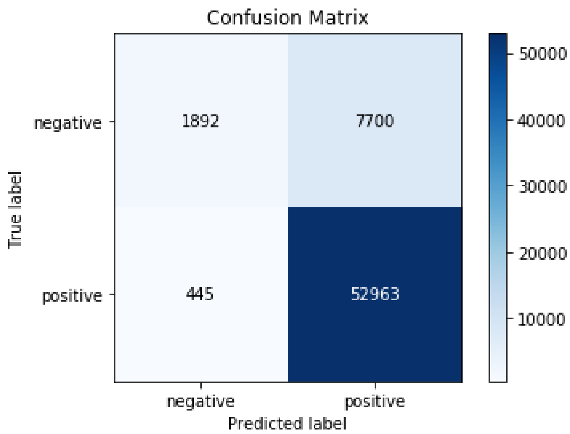
```
At Alpha =  0.01 accuracy is  90.14761904761905
```

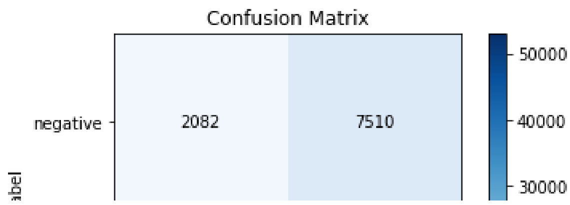


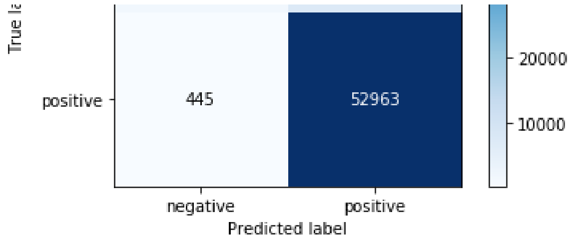
- Confusion matrix

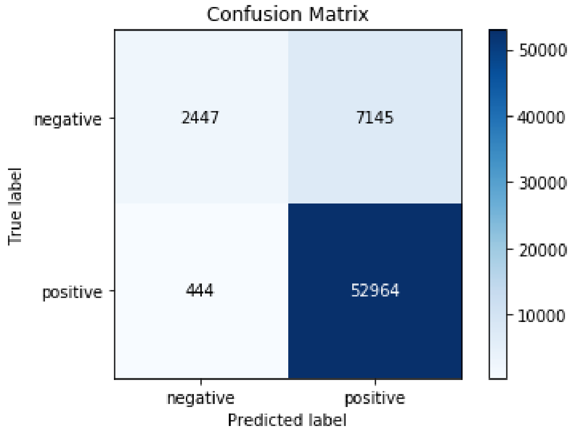
In [228]:

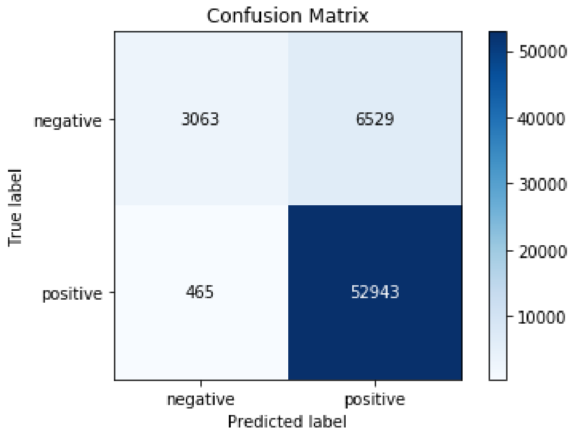
```
#cross validation for different alpha values using confusion matrix as performance metric.
alphas = [0.000001,0.00001, 0.0001, 0.001, 0.01, 1, 10, 100]
for alpha in alphas:
    nb = MultinomialNB(alpha=alpha)
    nb.fit(tf_idf_train, y_train)
    pred = nb.predict(tf_idf_cv)
    skplt.metrics.plot_confusion_matrix(y_cv, pred, normalize=False)
```

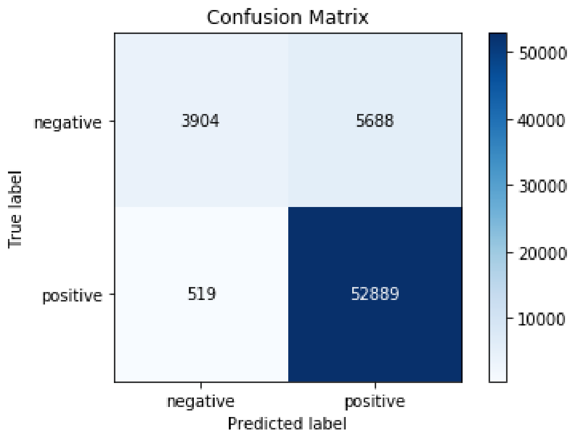


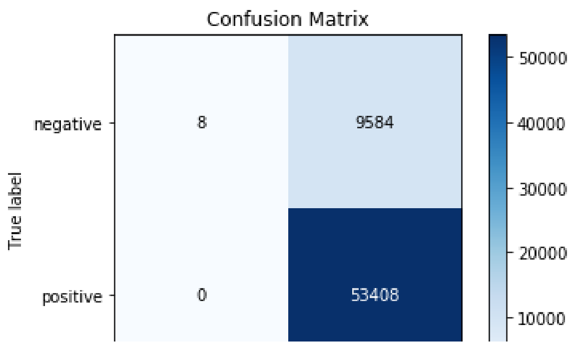


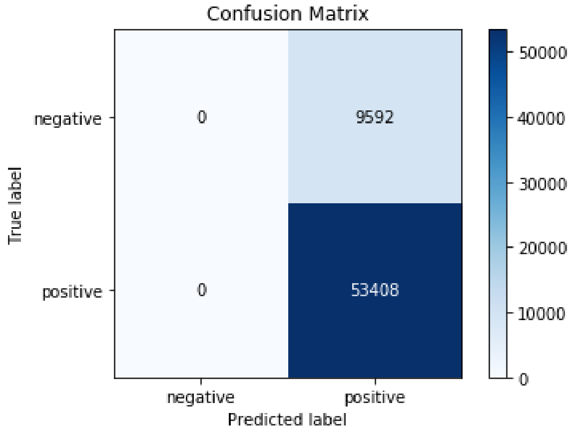

True la
positive
445
52963
20000
10000
negative
positive
Predicted label

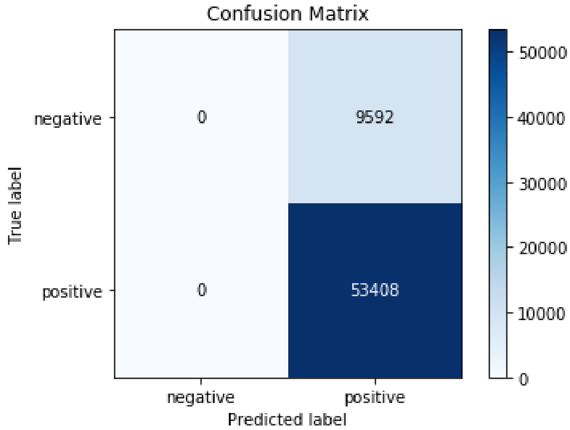

Confusion Matrix
negative
positive
True label
2447
7145
444
52964
50000
40000
30000
20000
10000
negative
positive
Predicted label


Confusion Matrix
negative
positive
True label
3063
6529
465
52943
50000
40000
30000
20000
10000
negative
positive
Predicted label


Confusion Matrix
negative
positive
True label
3904
5688
519
52889
50000
40000
30000
20000
10000
negative
positive
Predicted label


Confusion Matrix
negative
positive
True label
8
9584
0
53408
50000
40000
30000
20000
10000





- f1-score

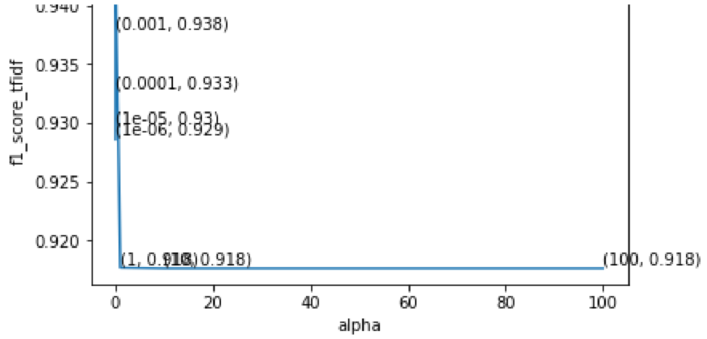
In [233]:

```
alphas = [0.000001,0.00001, 0.0001, 0.001, 0.01, 1, 10, 100]
f1_score_tfidf = []
for alpha in alphas:
    nb = MultinomialNB(alpha=alpha)
    nb.fit(tf_idf_train, y_train)
    pred = nb.predict(tf_idf_cv)
    tn, fp, fn, tp = confusion_matrix(y_cv, pred).ravel()
    pr,re = (tp)/(tp+fp),(tp)/(tp+fn)
    score=(2*pr*re)/(pr+re)
    f1_score_tfidf.append(score)
```

In [237]:

```
alpha_tfidf = alphas[f1_score_tfidf.index(max(f1_score_tfidf))]
print('At Alpha = ',alpha_tfidf,'f1_score is ',max(f1_score_tfidf))

plt.plot(alphas,f1_score_tfidf)
for xy in zip(alphas, np.round(f1_score_tfidf,3)):
    plt.annotate('(%s, %s)' % xy, xy=xy, textcoords='data')
plt.xlabel('alpha')
plt.ylabel('f1_score_tfidf')
plt.show()
```

```
At Alpha =  0.01 f1_score is  0.9445729338750725
```



In [243]:

```
f1_score_tfidf_train = max(f1_score_tfidf)
```

In [238]:

```
tf_idf_test = tf_idf_vect.transform(X_test)
print(tf_idf_test.shape)
```

```
(90000, 1631076)
```

- Performing Naive Bayes for best alpha value.

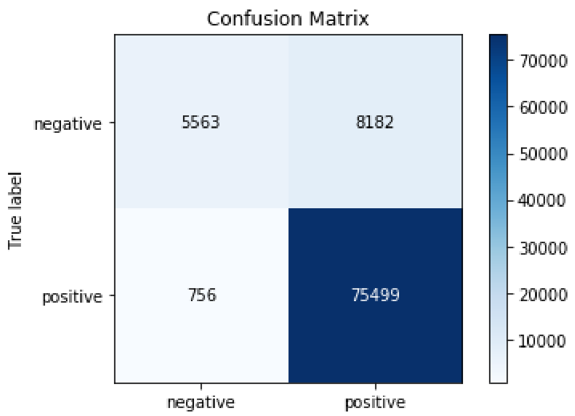
In [246]:

```
#Performing K-NN for optimal k-value using test data
nb = MultinomialNB(alpha=0.01)
nb.fit(tf_idf_train, y_train)

#predicting using test data
pred = nb.predict(tf_idf_test)

#Accuracy
acc = accuracy_score(y_test,pred, normalize=True) * float(100)
print('accuracy for alpha = 1 is',(acc))

#f1-score
tn, fp, fn, tp = confusion_matrix(y_test, pred).ravel()
pr,re = (tp)/(tp+fp),(tp)/(tp+fn)
f1_score_tfidf_test=(2*pr*re)/(pr+re)
print('f1 score for alpha = 1 is',(f1_score_tfidf_test))

#confusion matrix
skplt.metrics.plot_confusion_matrix(y_test, pred, normalize=False)
```

```
accuracy for alpha = 1 is 90.06888888888889
f1 score for alpha = 1 is 0.9441151460584233
```

Out[246]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x202c0a63f98>
```



Predicted label

Feature importance

In [221]:

```
neg_probs = nb.feature_log_prob_[0, :].argsort()
print(np.take(count_vect.get_feature_names(), neg_probs[0]))
pos_probs = nb.feature_log_prob_[1, :].argsort()
print(np.take(count_vect.get_feature_names(), pos_probs[0]))
```

```
aaa
ligo
```

Conclusions

In [247]:

```
from prettytable import PrettyTable

Table = PrettyTable()

Table.field_names  = ["Model", "Hyper_parameter(K)", "Train f1-score", "Test f1-score"]

Table.add_row(["BOW", alpha_bow, f1_score_bow_train,f1_score_bow_test])
Table.add_row(["TF_IDF", alpha_tfidf, f1_score_tfidf_train,f1_score_tfidf_test])

print(Table)
```

```
+--------+--------------------+--------------------+--------------------+
| Model  | Hyper_parameter(K) |   Train f1-score   |    Test f1-score   |
+--------+--------------------+--------------------+--------------------+
|  BOW   |         1          | 0.9448527014818333 | 0.9439662194303438 |
| TF_IDF |        0.01        | 0.9445729338750725 | 0.9441151460584233 |
+--------+--------------------+--------------------+--------------------+
```