In [1]:
```
import pandas as pd
import numpy as np
import re
import seaborn as sns
import matplotlib.pyplot as plt
from matplotlib import style
style.use('ggplot')
from textblob import TextBlob
from nltk.tokenize import word_tokenize
from nltk.stem import PorterStemmer
from nltk.corpus import stopwords
stop_words = set(stopwords.words('english'))
from wordcloud import WordCloud
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score, classification_report, confusion
```

In [2]:
```
df = pd.read_csv('vaccination_tweets.csv')
```

In [3]:
```
df.head()
```

Out[3]:

	id	user_name	user_location	user_description	user_created	user_f
0	1340539111971516416	Rachel Roh	La Crescenta-Montrose, CA	Aggregator of Asian American news; scanning di...	2009-04-08 17:52:46	
1	1338158543359250433	Albert Fong	San Francisco, CA	Marketing dude, tech geek, heavy metal & '80s ...	2009-09-21 15:27:30	
2	1337858199140118533	eliLTEU 👌	Your Bed	heil, hydra 🖐 ☺	2020-06-25 23:30:28	
3	1337855739918835717	Charles Adler	Vancouver, BC - Canada	Hosting "CharlesAdlerTonight" Global News Radi...	2008-09-10 11:28:53	
4	1337854064604966912	Citizen News Channel	NaN	Citizen News Channel bringing you an alternati...	2020-04-23 17:58:42	

In [4]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 11020 entries, 0 to 11019
Data columns (total 16 columns):
 #   Column            Non-Null Count  Dtype 
---  ------            --------------  ----- 
 0   id                11020 non-null  int64 
 1   user_name         11020 non-null  object
 2   user_location     8750 non-null   object
 3   user_description  10341 non-null  object
 4   user_created      11020 non-null  object
 5   user_followers    11020 non-null  int64 
 6   user_friends      11020 non-null  int64 
 7   user_favourites   11020 non-null  int64 
 8   user_verified     11020 non-null  bool  
 9   date              11020 non-null  object
 10  text              11020 non-null  object
 11  hashtags          8438 non-null   object
 12  source            11019 non-null  object
 13  retweets          11020 non-null  int64 
 14  favorites         11020 non-null  int64 
 15  is_retweet        11020 non-null  bool  
dtypes: bool(2), int64(6), object(8)
memory usage: 1.2+ MB
```

In [5]:
```
df.isnull().sum()
```

Out[5]:
```
id                     0
user_name              0
user_location       2270
user_description     679
user_created           0
user_followers         0
user_friends           0
user_favourites        0
user_verified          0
date                   0
text                   0
hashtags            2582
source                 1
retweets               0
favorites              0
is_retweet             0
dtype: int64
```

In [6]:
```
df.columns
```

Out[6]:
```
Index(['id', 'user_name', 'user_location', 'user_description', 'user_creat
ed',
       'user_followers', 'user_friends', 'user_favourites', 'user_verifie
d',
       'date', 'text', 'hashtags', 'source', 'retweets', 'favorites',
       'is_retweet'],
      dtype='object')
```

In [7]:
```
text_df = df.drop(['id', 'user_name', 'user_location', 'user_description', '
          'user_followers', 'user_friends', 'user_favourites', 'user_verified',
          'date', 'hashtags', 'source', 'retweets', 'favorites',
          'is_retweet'], axis=1)
text_df.head()
```

Out[7]:

	text
0	Same folks said daikon paste could treat a cyt...
1	While the world has been on the wrong side of ...
2	#coronavirus #SputnikV #AstraZeneca #PfizerBio...
3	Facts are immutable, Senator, even when you're...
4	Explain to me again why we need a vaccine @Bor...

In [8]:
```
print(text_df['text'].iloc[0],"\n")
print(text_df['text'].iloc[1],"\n")
print(text_df['text'].iloc[2],"\n")
print(text_df['text'].iloc[3],"\n")
print(text_df['text'].iloc[4],"\n")
```

```
Same folks said daikon paste could treat a cytokine storm #PfizerBioNTech
https://t.co/xeHhIMg1kF (https://t.co/xeHhIMg1kF)

While the world has been on the wrong side of history this year, hopefull
y, the biggest vaccination effort we've ev… https://t.co/dlCHrZjkhm (http
s://t.co/dlCHrZjkhm)

#coronavirus #SputnikV #AstraZeneca #PfizerBioNTech #Moderna #Covid_19 Rus
sian vaccine is created to last 2-4 years… https://t.co/ieYlCKBr8P (http
s://t.co/ieYlCKBr8P)

Facts are immutable, Senator, even when you're not ethically sturdy enough
to acknowledge them. (1) You were born i… https://t.co/jqgV18kch4 (http
s://t.co/jqgV18kch4)

Explain to me again why we need a vaccine @BorisJohnson @MattHancock #wher
eareallthesickpeople #PfizerBioNTech… https://t.co/KxbSRoBEHq (https://t.c
o/KxbSRoBEHq)
```

In [9]:
```
text_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 11020 entries, 0 to 11019
Data columns (total 1 columns):
 #   Column  Non-Null Count  Dtype 
---  ------  --------------  ----- 
 0   text    11020 non-null  object
dtypes: object(1)
memory usage: 86.2+ KB
```

In [10]:
```
def data_processing(text):
    text = text.lower()
    text = re.sub(r"https\S+|www\S+https\S+", '',text, flags=re.MULTILINE)
    text = re.sub(r'\@w+|\#','',text)
    text = re.sub(r'[^\w\s]','',text)
    text_tokens = word_tokenize(text)
    filtered_text = [w for w in text_tokens if not w in stop_words]
    return " ".join(filtered_text)
```

In [11]:
```
text_df.text = text_df['text'].apply(data_processing)
```

In [12]:
```
text_df = text_df.drop_duplicates('text')
```

In [13]:
```
stemmer = PorterStemmer()
def stemming(data):
    text = [stemmer.stem(word) for word in data]
    return data
```

In [14]:
```
text_df['text'] = text_df['text'].apply(lambda x: stemming(x))
```

In [15]:
```
text_df.head()
```

Out[15]:

	text
0	folks said daikon paste could treat cytokine s...
1	world wrong side history year hopefully bigges...
2	coronavirus sputnikv astrazeneca pfizerbiontec...
3	facts immutable senator even youre ethically s...
4	explain need vaccine borisjohnson matthancock ...

In [16]:
```
print(text_df['text'].iloc[0],"\n")
print(text_df['text'].iloc[1],"\n")
print(text_df['text'].iloc[2],"\n")
print(text_df['text'].iloc[3],"\n")
print(text_df['text'].iloc[4],"\n")
```

```
folks said daikon paste could treat cytokine storm pfizerbiontech

world wrong side history year hopefully biggest vaccination effort weve ev

coronavirus sputnikv astrazeneca pfizerbiontech moderna covid_19 russian v
accine created last 24 years

facts immutable senator even youre ethically sturdy enough acknowledge 1 b
orn

explain need vaccine borisjohnson matthancock wherearealltthesickpeople pfi
zerbiontech
```

In [17]:
```
text_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 10543 entries, 0 to 11019
Data columns (total 1 columns):
 #   Column  Non-Null Count  Dtype 
---  ------  --------------  ----- 
 0   text    10543 non-null  object
dtypes: object(1)
memory usage: 164.7+ KB
```

In [18]:
```
def polarity(text):
    return TextBlob(text).sentiment.polarity
```

In [19]:
```
text_df['polarity'] = text_df['text'].apply(polarity)
```

In [20]:
```
text_df.head(10)
```

Out[20]:

	text	polarity
0	folks said daikon paste could treat cytokine s...	0.000
1	world wrong side history year hopefully bigges...	-0.500
2	coronavirus sputnikv astrazeneca pfizerbiontec...	0.000
3	facts immutable senator even youre ethically s...	0.100
4	explain need vaccine borisjohnson matthancock ...	0.000
5	anyone useful adviceguidance whether covid vac...	0.400
6	bit sad claim fame success vaccination patriot...	-0.100
7	many bright days 2020 best 1 bidenharris winni...	0.675
8	covid vaccine getting covidvaccine covid19 pfi...	0.000
9	covidvaccine states start getting covid19vacci...	0.000

In [21]:
```
def sentiment(label):
    if label <0:
        return "Negative"
    elif label ==0:
        return "Neutral"
    elif label>0:
        return "Positive"
```

In [22]:
```
text_df['sentiment'] = text_df['polarity'].apply(sentiment)
```

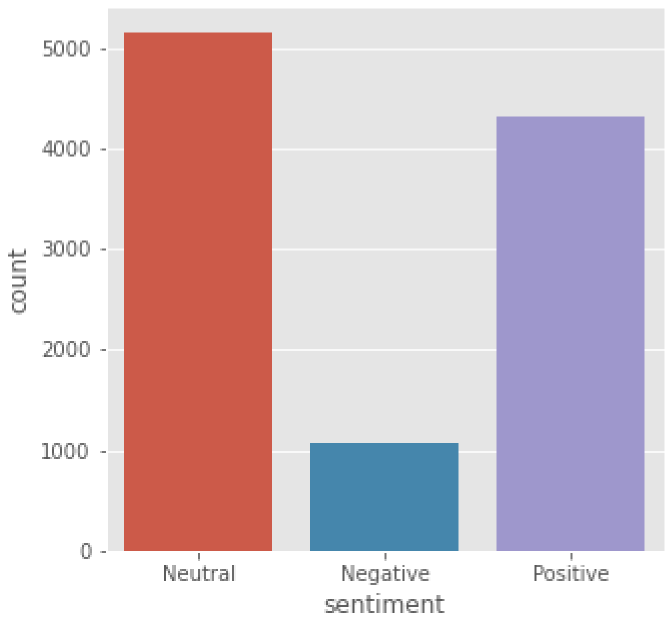
In [23]:
```
text_df.head()
```

Out[23]:

	text	polarity	sentiment
0	folks said daikon paste could treat cytokine s...	0.0	Neutral
1	world wrong side history year hopefully bigges...	-0.5	Negative
2	coronavirus sputnikv astrazeneca pfizerbiontec...	0.0	Neutral
3	facts immutable senator even youre ethically s...	0.1	Positive
4	explain need vaccine borisjohnson matthancock ...	0.0	Neutral

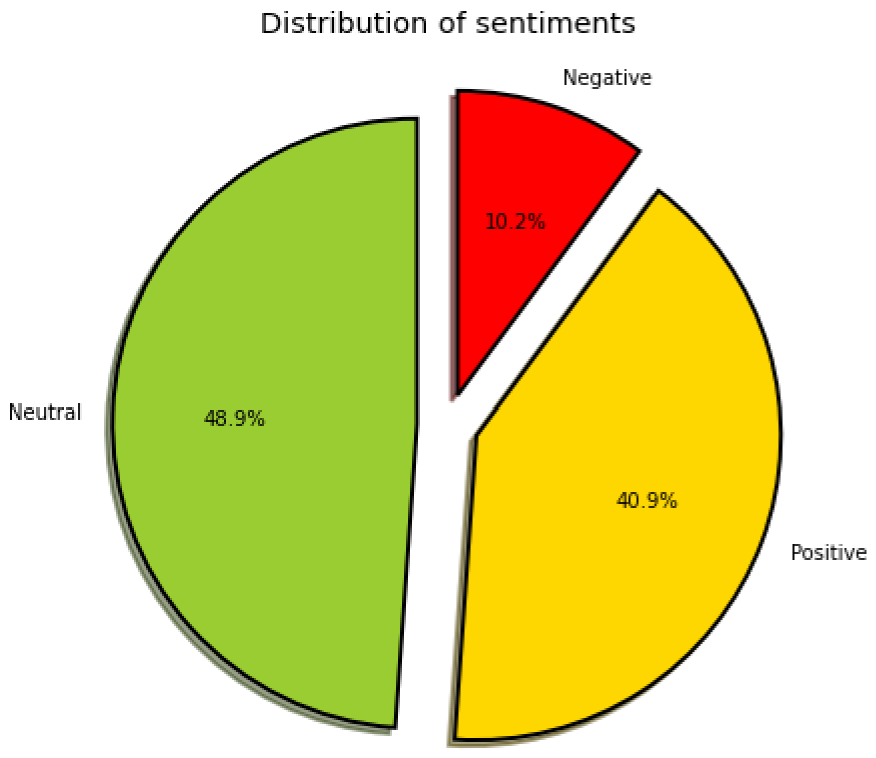
In [24]:
```
fig = plt.figure(figsize=(5,5))
sns.countplot(x='sentiment', data = text_df)
```

Out[24]:
```
<AxesSubplot:xlabel='sentiment', ylabel='count'>
```



In [26]:
```
fig = plt.figure(figsize=(7,7))
colors = ("yellowgreen", "gold", "red")
wp = {'linewidth':2, 'edgecolor':"black"}
tags = text_df['sentiment'].value_counts()
explode = (0.1,0.1,0.1)
tags.plot(kind='pie', autopct='%1.1f%%', shadow=True, colors = colors,
         startangle=90, wedgeprops = wp, explode = explode, label='')
plt.title('Distribution of sentiments')
```

Out[26]:
```
Text(0.5, 1.0, 'Distribution of sentiments')
```



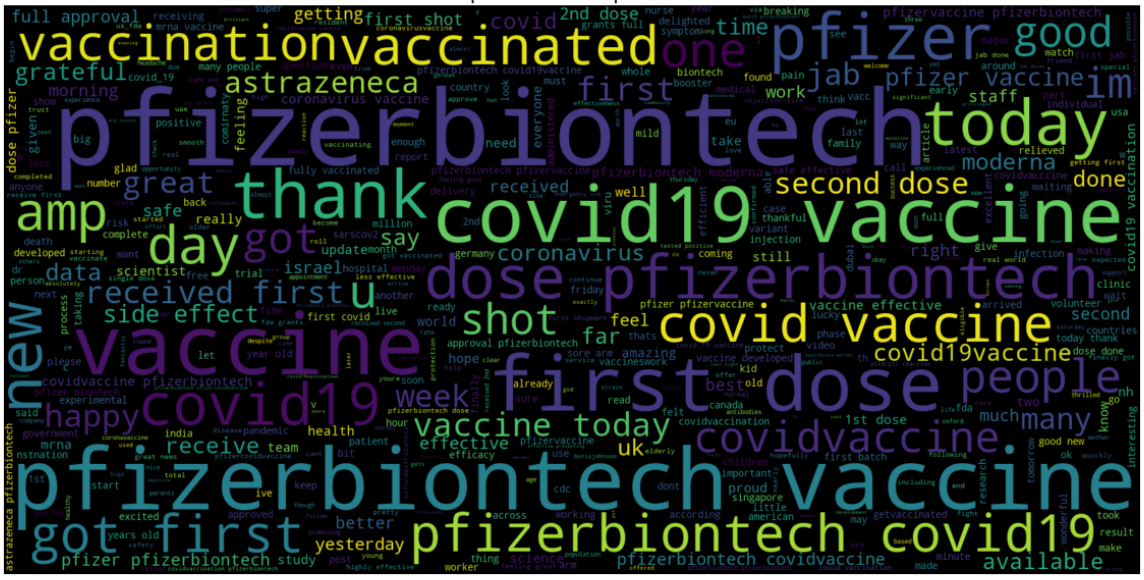
In [27]:
```
pos_tweets = text_df[text_df.sentiment == 'Positive']
pos_tweets = pos_tweets.sort_values(['polarity'], ascending= False)
pos_tweets.head()
```

Out[27]:

	text	polarity	sentiment
9317	best way get merrygoround pfizer pfizerbiontec...	1.0	Positive
2340	applying emotion pfizerbiontech based best evi...	1.0	Positive
6295	pfizer jab morning efficient wellorganised tha...	1.0	Positive
5041	get art printed awesome products support redbu...	1.0	Positive
1055	already vaccinated getting vaccine soon plan t...	1.0	Positive

In [28]:
```
text = ' '.join([word for word in pos_tweets['text']])
plt.figure(figsize=(20,15), facecolor='None')
wordcloud = WordCloud(max_words=500, width=1600, height=800).generate(text)
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis("off")
plt.title('Most frequent words in positive tweets', fontsize=19)
plt.show()
```

Most frequent words in positive tweets



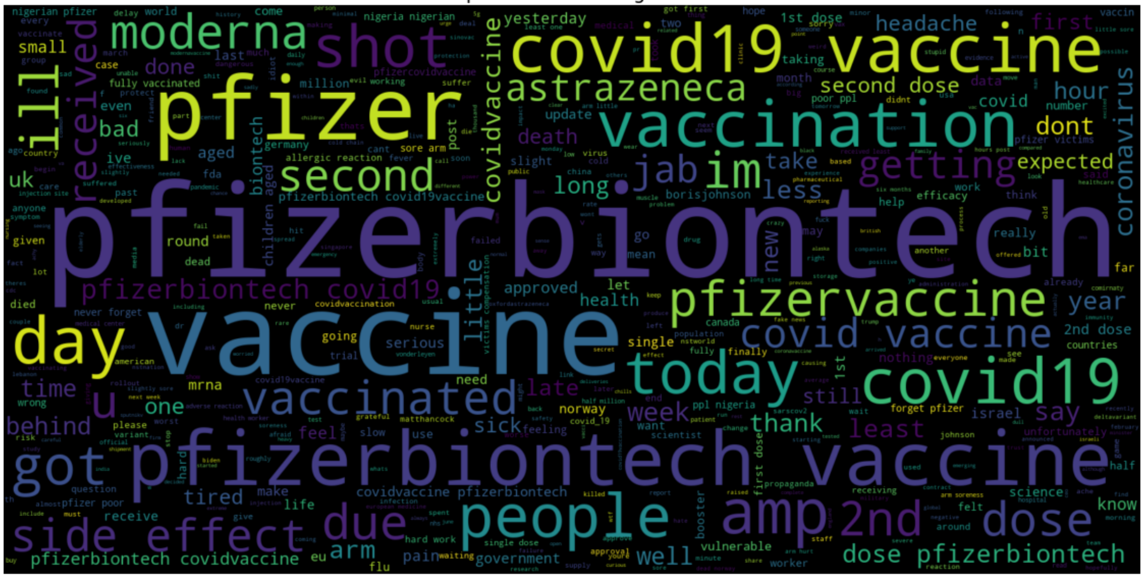
In [29]:
```
neg_tweets = text_df[text_df.sentiment == 'Negative']
neg_tweets = neg_tweets.sort_values(['polarity'], ascending= False)
neg_tweets.head()
```

Out[29]:

	text	polarity	sentiment
2912	work skilled nursing facility got first vaccin...	-0.003333	Negative
7256	200321 752308 vaccinations new daily record da...	-0.003409	Negative
2073	ukgovernment cant even vaccinate properly ethi...	-0.004762	Negative
7715	got first dose less waiting time airport vacci...	-0.005556	Negative
7157	nas_k27 second dose due end next month well fa...	-0.006250	Negative

In [30]:
```
text = ' '.join([word for word in neg_tweets['text']])
plt.figure(figsize=(20,15), facecolor='None')
wordcloud = WordCloud(max_words=500, width=1600, height=800).generate(text)
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis("off")
plt.title('Most frequent words in negative tweets', fontsize=19)
plt.show()
```

Most frequent words in negative tweets



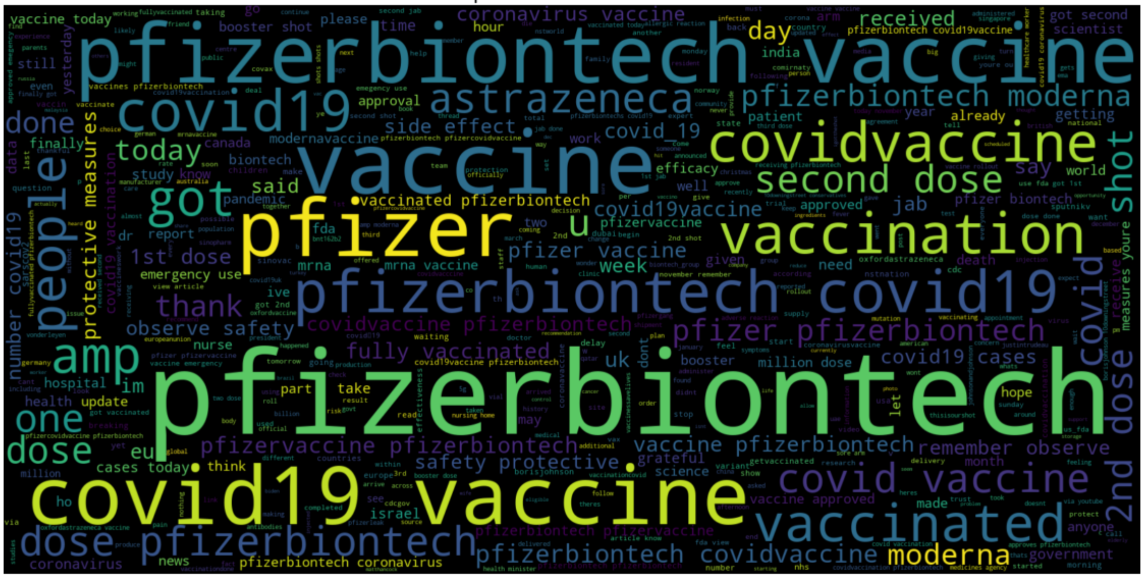
In [31]:
```
neutral_tweets = text_df[text_df.sentiment == 'Neutral']
neutral_tweets = neutral_tweets.sort_values(['polarity'], ascending= False)
neutral_tweets.head()
```

Out[31]:

	text	polarity	sentiment
0	folks said daikon paste could treat cytokine s...	0.0	Neutral
7347	anyone else feel like framing vaccine card pfi...	0.0	Neutral
7458	looking forward getting second pfizer shot any...	0.0	Neutral
7454	never thought id running diff vaccine modernav...	0.0	Neutral
7453	john___m dont get choose one person know asked...	0.0	Neutral

In [32]:
```
text = ' '.join([word for word in neutral_tweets['text']])
plt.figure(figsize=(20,15), facecolor='None')
wordcloud = WordCloud(max_words=500, width=1600, height=800).generate(text)
plt.imshow(wordcloud, interpolation='bilinear')
plt.axis("off")
plt.title('Most frequent words in neutral tweets', fontsize=19)
plt.show()
```

Most frequent words in neutral tweets



In [33]:
```
vect = CountVectorizer(ngram_range=(1,2)).fit(text_df['text'])
```

In [34]:
```
feature_names = vect.get_feature_names()
print("Number of features: {}\n".format(len(feature_names)))
print("First 20 features:\n {}".format(feature_names[:20]))
```

```
Number of features: 78583

First 20 features:
 ['000', '000 doses', '000 initial', '000 people', '000 vaccines', '000000
1', '0000001 covid19', '0011', '0011 abt', '004', '004 covid', '004 israel
is', '01', '01 getting', '01 june', '01 november', '01aug2021', '01aug2021
doublevaxxed', '02', '02 175']
```

In [35]:
```
X = text_df['text']
Y = text_df['sentiment']
X = vect.transform(X)
```

In [36]:
```
x_train, x_test, y_train, y_test = train_test_split(X, Y, test_size=0.2, rar
```

In [37]:
```
print("Size of x_train:", (x_train.shape))
print("Size of y_train:", (y_train.shape))
print("Size of x_test:", (x_test.shape))
print("Size of y_test:", (y_test.shape))
```

```
Size of x_train: (8434, 78583)
Size of y_train: (8434,)
Size of x_test: (2109, 78583)
Size of y_test: (2109,)
```

In [39]:
```
import warnings
warnings.filterwarnings('ignore')
```

In [40]:
```
logreg = LogisticRegression()
logreg.fit(x_train, y_train)
logreg_pred = logreg.predict(x_test)
logreg_acc = accuracy_score(logreg_pred, y_test)
print("Test accuracy: {:.2f}%".format(logreg_acc*100))
```

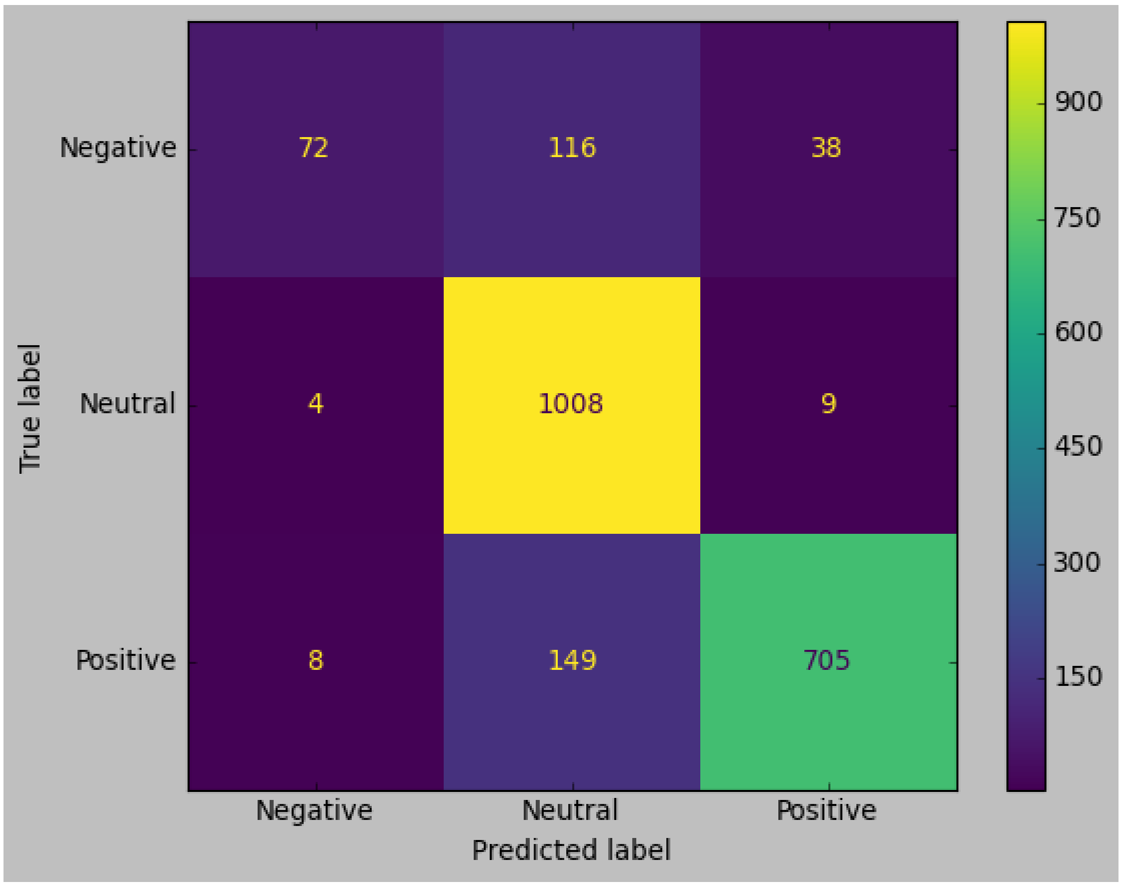
```
Test accuracy: 84.64%
```

In [41]:
```
print(confusion_matrix(y_test, logreg_pred))
print("\n")
print(classification_report(y_test, logreg_pred))
```

```
[[  72  116   38]
 [   4 1008    9]
 [   8  149  705]]


              precision    recall  f1-score   support

    Negative       0.86      0.32      0.46       226
     Neutral       0.79      0.99      0.88      1021
    Positive       0.94      0.82      0.87       862

    accuracy                           0.85      2109
   macro avg       0.86      0.71      0.74      2109
weighted avg       0.86      0.85      0.83      2109
```

In [43]:
```
style.use('classic')
cm = confusion_matrix(y_test, logreg_pred, labels=logreg.classes_)
disp = ConfusionMatrixDisplay(confusion_matrix = cm, display_labels=logreg.c
disp.plot()
```

Out[43]:
```
<sklearn.metrics._plot.confusion_matrix.ConfusionMatrixDisplay at 0x15ac0e
79190>
```



In [44]:
```
from sklearn.model_selection import GridSearchCV
```

In [45]:
```
param_grid={'C':[0.001, 0.01, 0.1, 1, 10]}
grid = GridSearchCV(LogisticRegression(), param_grid)
grid.fit(x_train, y_train)
```

Out[45]:
```
GridSearchCV(estimator=LogisticRegression(),
             param_grid={'C': [0.001, 0.01, 0.1, 1, 10]})
```

In [46]:
```
print("Best parameters:", grid.best_params_)
```

```
Best parameters: {'C': 10}
```

In [47]:
```
y_pred = grid.predict(x_test)
```

In [48]:
```
logreg_acc = accuracy_score(y_pred, y_test)
print("Test accuracy: {:.2f}%".format(logreg_acc*100))
```

```
Test accuracy: 85.92%
```

In [50]:
```
print(confusion_matrix(y_test, y_pred))
print("\n")
print(classification_report(y_test, y_pred))
```

```
[[  84  104   38]
 [   4 1008    9]
 [  10  132  720]]


              precision    recall  f1-score   support

    Negative       0.86      0.37      0.52       226
     Neutral       0.81      0.99      0.89      1021
    Positive       0.94      0.84      0.88       862

    accuracy                           0.86      2109
   macro avg       0.87      0.73      0.76      2109
weighted avg       0.87      0.86      0.85      2109
```

In [51]:
```
from sklearn.svm import LinearSVC
```

In [52]:
```
SVCmodel = LinearSVC()
SVCmodel.fit(x_train, y_train)
```

Out[52]:
```
LinearSVC()
```

In [53]:
```
svc_pred = SVCmodel.predict(x_test)
svc_acc = accuracy_score(svc_pred, y_test)
print("test accuracy: {:.2f}%".format(svc_acc*100))
```

```
test accuracy: 87.34%
```

In [54]:
```
print(confusion_matrix(y_test, svc_pred))
print("\n")
print(classification_report(y_test, svc_pred))
```

```
[[ 101   91   34]
 [   6 1007    8]
 [  14  114  734]]


              precision    recall  f1-score   support

    Negative       0.83      0.45      0.58       226
     Neutral       0.83      0.99      0.90      1021
    Positive       0.95      0.85      0.90       862

    accuracy                           0.87      2109
   macro avg       0.87      0.76      0.79      2109
weighted avg       0.88      0.87      0.87      2109
```

In [55]:
```
grid = {
    'C':[0.01, 0.1, 1, 10],
    'kernel':["linear","poly","rbf","sigmoid"],
    'degree':[1,3,5,7],
    'gamma':[0.01,1]
}
grid = GridSearchCV(SVCmodel, param_grid)
grid.fit(x_train, y_train)
```

Out[55]:
```
GridSearchCV(estimator=LinearSVC(), param_grid={'C': [0.001, 0.01, 0.1, 1,
10]})
```

In [56]:
```
print("Best parameter:", grid.best_params_)
```

```
Best parameter: {'C': 10}
```

In [57]:
```
y_pred = grid.predict(x_test)
```

In [58]:
```
logreg_acc = accuracy_score(y_pred, y_test)
print("Test accuracy: {:.2f}%".format(logreg_acc*100))
```

```
Test accuracy: 87.58%
```

In [59]:
```
print(confusion_matrix(y_test, y_pred))
print("\n")
print(classification_report(y_test, y_pred))
```

```
[[ 105   87   34]
 [   7 1005    9]
 [  14  111  737]]


              precision    recall  f1-score   support

    Negative       0.83      0.46      0.60       226
     Neutral       0.84      0.98      0.90      1021
    Positive       0.94      0.85      0.90       862

    accuracy                           0.88      2109
   macro avg       0.87      0.77      0.80      2109
weighted avg       0.88      0.88      0.87      2109
```

In [ ]: