```
Perform sentiment analysis on the amazon alexa reviews
```

In [1]:

```
import pandas as pd
import numpy as np
import warnings
warnings.filterwarnings('ignore')
```

In [2]:

```
import nltk
nltk.download('punkt') #for word tokenization
nltk.download('stopwords') #for removing or getting list of stopwords
nltk.download('wordnet') #for lemmatization
```

```
[nltk_data] Downloading package punkt to
[nltk_data]     C:\Users\swapn\AppData\Roaming\nltk_data...
[nltk_data]   Package punkt is already up-to-date!
[nltk_data] Downloading package stopwords to
[nltk_data]     C:\Users\swapn\AppData\Roaming\nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
[nltk_data] Downloading package wordnet to
[nltk_data]     C:\Users\swapn\AppData\Roaming\nltk_data...
[nltk_data]   Package wordnet is already up-to-date!
```

Out[2]:

```
True
```

In [3]:

```
from nltk.tokenize import word_tokenize
from nltk.corpus import  stopwords
from nltk.stem import WordNetLemmatizer
import matplotlib.pyplot as plt
from wordcloud import WordCloud
```

In [4]:

```
df = pd.read_csv("alexa_reviews.csv")
```

In [5]:

```
df
```

Out[5]:

	Unnamed: 0	verified_reviews	feedback
0	0	Love my Echo!	1
1	1	Loved it!	1
2	2	Sometimes while playing a game, you can answer...	1
3	3	I have had a lot of fun with this thing. My 4 ...	1
4	4	Music	1
...	...	...	...
3145	3145	Perfect for kids, adults and everyone in betwe...	1
3146	3146	Listening to music, searching locations, check...	1
3147	3147	I do love these things, i have them running my...	1
3148	3148	Only complaint I have is that the sound qualit...	1
3149	3149	Good	1

3150 rows × 3 columns

In [6]:

```
df.drop(["Unnamed: 0"],axis=1,inplace=True)
```

In [7]:

```
df
```

Out[7]:

	verified_reviews	feedback
0	Love my Echo!	1
1	Loved it!	1
2	Sometimes while playing a game, you can answer...	1
3	I have had a lot of fun with this thing. My 4 ...	1
4	Music	1
...	...	...
3145	Perfect for kids, adults and everyone in betwe...	1
3146	Listening to music, searching locations, check...	1
3147	I do love these things, i have them running my...	1
3148	Only complaint I have is that the sound qualit...	1
3149	Good	1

3150 rows × 2 columns

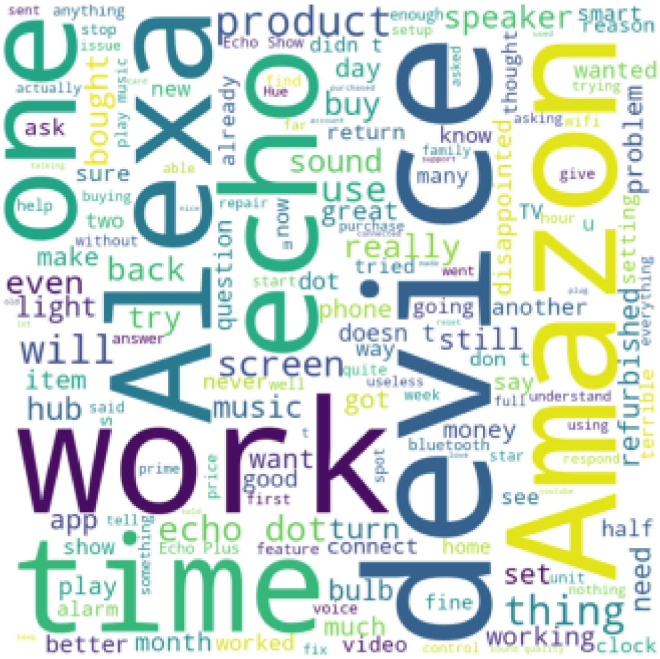
In [8]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 3150 entries, 0 to 3149
Data columns (total 2 columns):
 #   Column            Non-Null Count  Dtype 
---  ------            --------------  ----- 
 0   verified_reviews  3150 non-null   object
 1   feedback          3150 non-null   int64 
dtypes: int64(1), object(1)
memory usage: 49.3+ KB
```

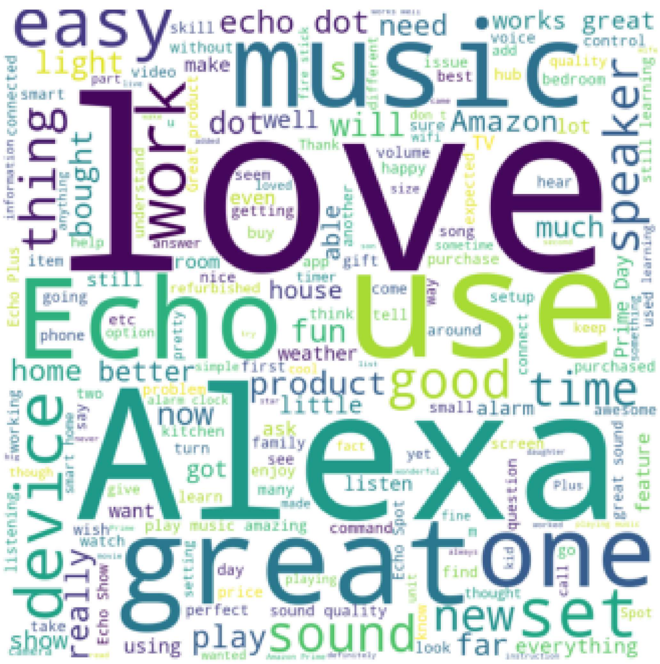
In [9]:

```
wc = WordCloud(width=800, height=800, background_color="white", min_font_size=10)
wc.generate("".join(df[df['feedback']==0]['verified_reviews']))

plt.figure(figsize=(6,6))
plt.imshow(wc)
plt.axis("off")
plt.show()
```



In [10]:

```
wc = WordCloud(width=800, height=800, background_color="white", min_font_size=10)
wc.generate("".join(df[df['feedback']==1]['verified_reviews']))

plt.figure(figsize=(6,6))
plt.imshow(wc)
plt.axis("off")
plt.show()
```



In [11]:

```
stop = stopwords.words("english")
def clean_text(text):
  tokens = word_tokenize(text.lower())
  # Filter only alphabets
  word_tokens = [t for t in tokens if t.isalpha()]
  clean_tokens = [t for t in word_tokens if t not in stop]
  lemma = WordNetLemmatizer()
  lemma_tokens = [lemma.lemmatize(t) for t in clean_tokens]
  return " ".join(lemma_tokens)
```

In [12]:

```
df['verified_reviews'] = df['verified_reviews'].apply(clean_text)
```

In [13]:

```
df['verified_reviews'].head()
```

Out[13]:

```
0                                            love echo
1                                                loved
2    sometimes playing game answer question correct...
3    lot fun thing yr old learns dinosaur control l...
4                                                music
Name: verified_reviews, dtype: object
```

In [14]:

```
x= df['verified_reviews']
y= df['feedback']
```

In [15]:

```
from sklearn.model_selection import train_test_split
x_train, x_test, y_train, y_test = train_test_split(x, y, test_size=0.3)
```

In [16]:

```
sent_len = []
for t in df['verified_reviews']:
  sent_len.append(len(word_tokenize(t)))
df['sent_len'] = sent_len
df.head()
```

Out[16]:

	verified_reviews	feedback	sent_len
0	love echo	1	2
1	loved	1	1
2	sometimes playing game answer question correct...	1	17
3	lot fun thing yr old learns dinosaur control l...	1	18
4	music	1	1

In [17]:

```
max(sent_len)
```

Out[17]:

```
245
```

In [18]:

```
np.quantile(sent_len, 0.95)
```

Out[18]:

```
40.0
```

In [19]:

```
max_len = 40
```

In [20]:

```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense
from tensorflow.keras.preprocessing.text import Tokenizer
# Creates dictionary and every unique word is given number key
from tensorflow.keras.preprocessing import sequence
# To perform the padding of the documents with zero's to make the length of the
# document common
from tensorflow.keras.layers import (LSTM, Dropout, Embedding, SimpleRNN, GRU)
# All the index numbers are converted to vectors using Embedding
# SimpleRNN allows to implement the RNN architecture - activation function -tanh
# Dropout - manage overfitting of model
```

In [21]:

```
# Tokenization
tok = Tokenizer(char_level=False, split=" ")
tok.fit_on_texts(x_train)
```

In [22]:

```
tok.index_word
```

Out[22]:

```
{1: 'love',
 2: 'echo',
 3: 'great',
 4: 'alexa',
 5: 'music',
 6: 'work',
 7: 'like',
 8: 'use',
 9: 'sound',
 10: 'device',
 11: 'one',
 12: 'dot',
 13: 'easy',
 14: 'speaker',
 15: 'set',
 16: 'good',
 17: 'get',
 18: 'thing',
```

In [23]:

```
vocab_len = len(tok.index_word)
vocab_len
```

Out[23]:

```
2987
```

In [24]:

```
seq_train = tok.texts_to_sequences(x_train)
seq_train
```

```
 [1, 118, 121, 208, 30],
 [1784,
  458,
  171,
  1243,
  162,
  39,
  1785,
  119,
  575,
  837,
  14,
  105,
  114,
  535,
  37,
  9,
  213,
  16,
  126,
```

In [25]:

```
seq_padded_train = sequence.pad_sequences(seq_train, maxlen=max_len)
seq_padded_train
```

Out[25]:

```
array([[   0,    0,    0, ...,    0,    1,   54],
       [   0,    0,    0, ...,   22,  237, 1780],
       [   0,    0,    0, ...,   26,  836, 1783],
       ...,
       [   0,    0,    0, ...,    0,    0,   90],
       [   0,    0,    0, ...,    0, 1639,  134],
       [   0,    0,    0, ...,   26,    4,  107]])
```

In [26]:

```
model = Sequential()
# vectorization
model.add(Embedding(vocab_len+1,40, input_length=max_len, mask_zero=True))
# RNN layer
model.add(SimpleRNN(32, activation="tanh"))
# ANN's hidden layer
model.add(Dense(32, activation="relu"))
# To check on overfitting
model.add(Dropout(0.2))
# output layer
model.add(Dense(1, activation="sigmoid"))
```

In [27]:

```
model.summary()
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
embedding (Embedding)        (None, 40, 40)            119520    
_________________________________________________________________
simple_rnn (SimpleRNN)       (None, 32)                2336      
_________________________________________________________________
dense (Dense)                (None, 32)                1056      
_________________________________________________________________
dropout (Dropout)            (None, 32)                0         
_________________________________________________________________
dense_1 (Dense)              (None, 1)                 33        
=================================================================
Total params: 122,945
Trainable params: 122,945
Non-trainable params: 0
_________________________________________________________________
```

In [28]:

```
model.compile(loss="binary_crossentropy", optimizer="adam")
```

In [29]:

```
model.fit(seq_padded_train, y_train, batch_size=50, epochs=50)
```

```
Epoch 1/50
45/45 [==============================] - 2s 11ms/step - loss: 0.5967
Epoch 2/50
45/45 [==============================] - 0s 10ms/step - loss: 0.3192
Epoch 3/50
45/45 [==============================] - 0s 10ms/step - loss: 0.2379
Epoch 4/50
45/45 [==============================] - 0s 10ms/step - loss: 0.1135
Epoch 5/50
45/45 [==============================] - 0s 10ms/step - loss: 0.0485
Epoch 6/50
45/45 [==============================] - 0s 11ms/step - loss: 0.0324
Epoch 7/50
45/45 [==============================] - 1s 12ms/step - loss: 0.0245
Epoch 8/50
45/45 [==============================] - 1s 12ms/step - loss: 0.0177
Epoch 9/50
45/45 [==============================] - 0s 9ms/step - loss: 0.0165
Epoch 10/50
45/45 [==============================] - 0s 9ms/step - loss: 0.0182
Epoch 11/50
45/45 [==============================] - 1s 11ms/step - loss: 0.0144
Epoch 12/50
45/45 [==============================] - 0s 11ms/step - loss: 0.0164
Epoch 13/50
45/45 [==============================] - 0s 10ms/step - loss: 0.0149
Epoch 14/50
45/45 [==============================] - 0s 10ms/step - loss: 0.0128
Epoch 15/50
45/45 [==============================] - 0s 10ms/step - loss: 0.0125
Epoch 16/50
45/45 [==============================] - 0s 9ms/step - loss: 0.0124
Epoch 17/50
45/45 [==============================] - 0s 9ms/step - loss: 0.0137
Epoch 18/50
45/45 [==============================] - 0s 11ms/step - loss: 0.0149
Epoch 19/50
45/45 [==============================] - 0s 9ms/step - loss: 0.0127
Epoch 20/50
45/45 [==============================] - 0s 10ms/step - loss: 0.0089
Epoch 21/50
45/45 [==============================] - 0s 10ms/step - loss: 0.0144
Epoch 22/50
45/45 [==============================] - 0s 10ms/step - loss: 0.0148
Epoch 23/50
45/45 [==============================] - 0s 10ms/step - loss: 0.0111
Epoch 24/50
45/45 [==============================] - 0s 10ms/step - loss: 0.0124
Epoch 25/50
45/45 [==============================] - 0s 10ms/step - loss: 0.0131
Epoch 26/50
45/45 [==============================] - 0s 10ms/step - loss: 0.0119
Epoch 27/50
45/45 [==============================] - 0s 10ms/step - loss: 0.0097
Epoch 28/50
45/45 [==============================] - 0s 9ms/step - loss: 0.0136
```

```
Epoch 29/50
45/45 [==============================] - 0s 9ms/step - loss: 0.0112
Epoch 30/50
45/45 [==============================] - 0s 10ms/step - loss: 0.0106
Epoch 31/50
45/45 [==============================] - 0s 10ms/step - loss: 0.0148
Epoch 32/50
45/45 [==============================] - 0s 9ms/step - loss: 0.0114
Epoch 33/50
45/45 [==============================] - 0s 9ms/step - loss: 0.0161
Epoch 34/50
45/45 [==============================] - 0s 9ms/step - loss: 0.0091
Epoch 35/50
45/45 [==============================] - 0s 9ms/step - loss: 0.0131
Epoch 36/50
45/45 [==============================] - 0s 9ms/step - loss: 0.0122
Epoch 37/50
45/45 [==============================] - 0s 9ms/step - loss: 0.0107
Epoch 38/50
45/45 [==============================] - 0s 9ms/step - loss: 0.0128
Epoch 39/50
45/45 [==============================] - 0s 9ms/step - loss: 0.0063
Epoch 40/50
45/45 [==============================] - 0s 9ms/step - loss: 0.0134
Epoch 41/50
45/45 [==============================] - 0s 9ms/step - loss: 0.0140
Epoch 42/50
45/45 [==============================] - 0s 9ms/step - loss: 0.0116
Epoch 43/50
45/45 [==============================] - 0s 9ms/step - loss: 0.0132
Epoch 44/50
45/45 [==============================] - 0s 9ms/step - loss: 0.0128
Epoch 45/50
45/45 [==============================] - 0s 10ms/step - loss: 0.0144
Epoch 46/50
45/45 [==============================] - 0s 10ms/step - loss: 0.0114
Epoch 47/50
45/45 [==============================] - 0s 9ms/step - loss: 0.0100
Epoch 48/50
45/45 [==============================] - 0s 10ms/step - loss: 0.0118
Epoch 49/50
45/45 [==============================] - 0s 10ms/step - loss: 0.0131
Epoch 50/50
45/45 [==============================] - 0s 9ms/step - loss: 0.0103
```

Out[29]:

```
<tensorflow.python.keras.callbacks.History at 0x1bd9979a5b0>
```

In [30]:

```
seq_test = tok.texts_to_sequences(x_test)
seq_test
```

Out[30]:

```
[[129, 4, 26, 149, 4, 2, 219, 7, 92, 44, 26],
 [1, 2, 13, 615, 537, 48, 450, 8, 716, 21, 153, 677, 944, 4, 1074],
 [43, 79, 21, 17, 72, 64, 205, 258, 22, 1049, 101, 60, 87, 29],
 [28, 1, 2, 12, 17, 101, 2762, 171, 313, 21, 5, 87],
 [1111, 91],
 [531,
  29,
  70,
  402,
  59,
  46,
  70,
  714,
  275,
  1539,
  900,
  30,
  268,
```

In [31]:

```
seq_padded_test = sequence.pad_sequences(seq_test, maxlen=max_len)
seq_padded_test
```

Out[31]:

```
array([[   0,    0,    0, ...,   92,   44,   26],
       [   0,    0,    0, ...,  944,    4, 1074],
       [   0,    0,    0, ...,   60,   87,   29],
       ...,
       [   0,    0,    0, ...,  500,    8, 1158],
       [   0,    0,    0, ...,    0,    0,  152],
       [   0,    0,    0, ...,  124,  169, 1096]])
```

In [32]:

```
y_hat = model.predict(seq_padded_test)
```

In [33]:

```
# y_hat contains probability
y_hat = np.where(y_hat>=0.5, 1, 0)
```

In [34]:

```
from sklearn.metrics import classification_report
print(classification_report( y_test, y_hat))
```

```
              precision    recall  f1-score   support

           0       0.44      0.29      0.35        83
           1       0.93      0.96      0.95       862

    accuracy                           0.90       945
   macro avg       0.69      0.63      0.65       945
weighted avg       0.89      0.90      0.90       945
```

In [35]:

```
model = Sequential()
# vectorization
model.add(Embedding(vocab_len+1,40, input_length=max_len, mask_zero=True))
# RNN layer
# model.add(SimpleRNN(32, activation="tanh"))
model.add(LSTM(32, activation="tanh"))
# ANN's hidden layer
model.add(Dense(32, activation="relu"))
# To check on overfitting
model.add(Dropout(0.2))
# output layer
model.add(Dense(1, activation="sigmoid"))
model.compile(loss="binary_crossentropy", optimizer="adam")
model.fit(seq_padded_train, y_train, batch_size=50, epochs=50)
```

```
Epoch 1/50
45/45 [==============================] - 6s 17ms/step - loss: 0.6283
Epoch 2/50
45/45 [==============================] - 1s 17ms/step - loss: 0.3489
Epoch 3/50
45/45 [==============================] - 1s 17ms/step - loss: 0.1870
Epoch 4/50
45/45 [==============================] - 1s 17ms/step - loss: 0.1322
Epoch 5/50
45/45 [==============================] - 1s 19ms/step - loss: 0.0805
Epoch 6/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0659
Epoch 7/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0291
Epoch 8/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0218: 0s -
loss: 0.021
Epoch 9/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0181
Epoch 10/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0180
Epoch 11/50
45/45 [==============================] - 1s 22ms/step - loss: 0.0167
Epoch 12/50
45/45 [==============================] - 1s 21ms/step - loss: 0.0161
Epoch 13/50
45/45 [==============================] - 1s 20ms/step - loss: 0.0134
Epoch 14/50
45/45 [==============================] - 1s 20ms/step - loss: 0.0129
Epoch 15/50
45/45 [==============================] - 1s 20ms/step - loss: 0.0166
Epoch 16/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0136
Epoch 17/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0127
Epoch 18/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0136
Epoch 19/50
45/45 [==============================] - 1s 20ms/step - loss: 0.0091
Epoch 20/50
45/45 [==============================] - 1s 18ms/step - loss: 0.0107
Epoch 21/50
45/45 [==============================] - 1s 20ms/step - loss: 0.0129
```

```
Epoch 22/50
45/45 [==============================] - 1s 18ms/step - loss: 0.0121
Epoch 23/50
45/45 [==============================] - 1s 19ms/step - loss: 0.0133
Epoch 24/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0154: 1s -
l
Epoch 25/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0088
Epoch 26/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0127
Epoch 27/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0173
Epoch 28/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0145
Epoch 29/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0140
Epoch 30/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0095TA: 0s
- loss
Epoch 31/50
45/45 [==============================] - 1s 20ms/step - loss: 0.0138
Epoch 32/50
45/45 [==============================] - 1s 18ms/step - loss: 0.0323
Epoch 33/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0206
Epoch 34/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0211
Epoch 35/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0124
Epoch 36/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0140
Epoch 37/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0138
Epoch 38/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0103
Epoch 39/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0104
Epoch 40/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0101: 0s -
lo
Epoch 41/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0117
Epoch 42/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0109: 0s -
los
Epoch 43/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0099
Epoch 44/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0130
Epoch 45/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0116
Epoch 46/50
45/45 [==============================] - 1s 20ms/step - loss: 0.0084
Epoch 47/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0109
Epoch 48/50
45/45 [==============================] - 1s 20ms/step - loss: 0.0112
Epoch 49/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0109
```

```
Epoch 50/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0093
```

Out[35]:

```
<tensorflow.python.keras.callbacks.History at 0x1bd9b24db20>
```

In [36]:

```
y_hat = model.predict(seq_padded_test)
y_hat = np.where(y_hat>=0.5, 1, 0)
print(classification_report(y_test, y_hat))
```

```
              precision    recall  f1-score   support

           0       0.65      0.34      0.44        83
           1       0.94      0.98      0.96       862

    accuracy                           0.93       945
   macro avg       0.80      0.66      0.70       945
weighted avg       0.91      0.93      0.92       945
```

In [37]:

```
model = Sequential()
# vectorization
model.add(Embedding(vocab_len+1,40, input_length=max_len, mask_zero=True))
# RNN layer
model.add(GRU(32, activation="tanh"))
# ANN's hidden layer
model.add(Dense(32, activation="relu"))
# To check on overfitting|
model.add(Dropout(0.2))
# output layer
model.add(Dense(1, activation="sigmoid"))
model.compile(loss="binary_crossentropy", optimizer="adam")
model.fit(seq_padded_train, y_train, batch_size=50, epochs=50)
```

```
Epoch 1/50
45/45 [==============================] - 5s 15ms/step - loss: 0.6134
Epoch 2/50
45/45 [==============================] - 1s 15ms/step - loss: 0.2745
Epoch 3/50
45/45 [==============================] - 1s 15ms/step - loss: 0.1893
Epoch 4/50
45/45 [==============================] - 1s 15ms/step - loss: 0.1218
Epoch 5/50
45/45 [==============================] - 1s 15ms/step - loss: 0.0736
Epoch 6/50
45/45 [==============================] - 1s 15ms/step - loss: 0.0387
Epoch 7/50
45/45 [==============================] - 1s 15ms/step - loss: 0.0255
Epoch 8/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0216
Epoch 9/50
45/45 [==============================] - 1s 15ms/step - loss: 0.0153
Epoch 10/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0174
Epoch 11/50
45/45 [==============================] - 1s 15ms/step - loss: 0.0164
Epoch 12/50
45/45 [==============================] - 1s 15ms/step - loss: 0.0156
Epoch 13/50
45/45 [==============================] - 1s 18ms/step - loss: 0.0156
Epoch 14/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0119
Epoch 15/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0146
Epoch 16/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0137
Epoch 17/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0138
Epoch 18/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0131
Epoch 19/50
45/45 [==============================] - 1s 15ms/step - loss: 0.0122
Epoch 20/50
45/45 [==============================] - 1s 15ms/step - loss: 0.0135
Epoch 21/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0130
Epoch 22/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0143
```

```
Epoch 23/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0123
Epoch 24/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0159
Epoch 25/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0127
Epoch 26/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0155 ETA: 0s
- l
Epoch 27/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0123
Epoch 28/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0129
Epoch 29/50
45/45 [==============================] - 1s 15ms/step - loss: 0.0107
Epoch 30/50
45/45 [==============================] - 1s 15ms/step - loss: 0.0130
Epoch 31/50
45/45 [==============================] - 1s 19ms/step - loss: 0.0103
Epoch 32/50
45/45 [==============================] - 1s 19ms/step - loss: 0.0115: 0s - l
oss: 0.0
Epoch 33/50
45/45 [==============================] - 1s 18ms/step - loss: 0.0143
Epoch 34/50
45/45 [==============================] - 1s 20ms/step - loss: 0.0124
Epoch 35/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0120: 0s -
Epoch 36/50
45/45 [==============================] - 1s 19ms/step - loss: 0.0164
Epoch 37/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0135
Epoch 38/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0135
Epoch 39/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0091
Epoch 40/50
45/45 [==============================] - 1s 15ms/step - loss: 0.0182
Epoch 41/50
45/45 [==============================] - 1s 19ms/step - loss: 0.0111
Epoch 42/50
45/45 [==============================] - 1s 19ms/step - loss: 0.0137
Epoch 43/50
45/45 [==============================] - 1s 19ms/step - loss: 0.0104
Epoch 44/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0104
Epoch 45/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0098
Epoch 46/50
45/45 [==============================] - 1s 17ms/step - loss: 0.0097
Epoch 47/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0089
Epoch 48/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0123
Epoch 49/50
45/45 [==============================] - 1s 19ms/step - loss: 0.0088
Epoch 50/50
45/45 [==============================] - 1s 16ms/step - loss: 0.0108
```

Out[37]:

```
<tensorflow.python.keras.callbacks.History at 0x1bda88e0d30>
```

In [38]:

```
y_hat = model.predict(seq_padded_test)
y_hat = np.where(y_hat>=0.5, 1, 0)
print(classification_report(y_test, y_hat))
```

```
              precision    recall  f1-score   support

           0       0.63      0.39      0.48        83
           1       0.94      0.98      0.96       862

    accuracy                           0.93       945
   macro avg       0.79      0.68      0.72       945
weighted avg       0.92      0.93      0.92       945
```

In [ ]:

```

```